NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

CASTAG
A COMPUTER ASSISTED INTERACTIVE NAVAL WARGAME

by

Kevin John Kelley

March 1980

Thesis Advisor: A. Andrus

Thesis
K27143

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CASTAG
A Computer Assisted Interactive Naval Wargame

by

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Lieutenant, United States Navy
B.A., University of Texas, 1973

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

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March 1980

ABSTRACT

CASTAG is an interactive two-sided computer wargame which models the movement and detection functions for the manual naval wargame SEATAG, developed at the Naval War College. CASTAG is programmed for the CP/CMS time sharing system on the IBM-360 at the Naval Postgraduate School.

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I. INTRODUCTION AND BACKGROUND

A. THE NEED FOR AN INTERACTIVE COMPUTER ASSISTED WARGAME AT THE NAVAL POSTGRADUATE SCHOOL

Several curricula at NPS study wargaming techniques. The courses include manual wargames and computer simulations as part of the course material. At the inception of this study, none of these courses had access to an interactive computer assisted wargame that could handle the mundane and time consuming plotting and computational chores of wargame bookkeeping.

The Warfare Environmental Simulator, WES, is currently being made available at the C^3 laboratory at the Naval Postgraduate School. The WES program is run at the Naval Ocean Systems Command (NOSC) in San Diego with outlying command centers such as the C^3 Lab and CINCPACLFT in Hawaii served by secure data link. WES games will be played on a strategic global or hemispheric scale and will try to approach real time data handling.

WES has several drawbacks for use in a general unclassified wargaming class at NPS. WES must be played in the C^3 laboratory and depends on an outside program located in NOSC's computers. The security requirements and limited use of the C^3 laboratory rule out extended use of WES at NPS. In addition, scheduling of WES games to support all curricula would require intercurricular scheduling and concurrence of NOSC.

There is therefore a void in interactive computer assisted wargames available at the Naval Postgraduate School. A medium scale naval wargame, tactical in scope and using the computer for bookkeeping functions is needed to fit the requirements of the wargaming courses. An additional requirement would be for a game to aid training of naval officers in tactical decision making. A game is needed that serves the traditional wargames functions of tactical analysis and education.

B. APPROACHES TO THE PROBLEM AND LIMITS OF THE THESIS

In this thesis the existing manual game SEATAG is partially programmed and implemented on the hardware currently installed at the Naval Postgraduate School's computing facility. The program requires less than two cylinders of disk space and is a self-contained game employing two terminals with appropriate screening of information. Changes in game parameters can be entered during overall program execution. The program calculates movement and processes all detections, with actual engagement results and damage determinations computed manually. The program also provides hard copy output for the participants.

C. SELECTION OF SEATAG

Selection of an existing manual game to convert to an interactive computer assisted program rather than the development of a new game was necessitated by this project's

completion date. SEATAG, a publication of the Naval War College, was selected. SEATAG has the advantage of being an official publication with reasonable and accepted assumptions and methodology. The SEATAG model used for this thesis is unclassified and does not contain classified performance data on the various platforms. SEATAG appealed to the author since it emphasized those items considered important without getting involved in a morass of detail.

Although there was a constant temptation to improve SEATAG in writing this thesis, the computer program is as consistent as possible with the rules, procedures and assumptions of the manual game.

Throughout the remainder of the thesis, SEATAG will refer to the manual game in its second edition from the Naval War College and CASTAG, for Computer Assisted SEATAG, will refer to the game as programmed in this thesis.

D. CHAPTER OUTLINE

Chapter II of this thesis examines SEATAG in terms of the playing area, scale, game flow and procedures for engagements and damage. Chapter III describes CASTAG with descriptions of all CASTAG subprograms and models as well as how interactive two terminal operation was achieved. Chapter IV is a user's guide to the CASTAG program with emphasis on the inputs and outputs. Chapter IV with a copy of the SEATAG rules is sufficient documentation to play CASTAG. Chapter V includes comments on playability and suggestions for additions and improvements to the CASTAG program.

II. SEATAG, THE MANUAL GAME

A. HISTORY AND DEVELOPMENT OF SEATAG

SEATAG, Sea Control Tactical Analysis Game, is currently in its second edition. SEATAG is published by the Center for Advanced Research of the Naval War College.

SEATAG was originally developed in 1975 as a research and analytical tool for evaluating the then new Harpoon anti-shipping missile tactics. The second edition is an improved and revised game which is available in an unclassified version.

B. DESCRIPTION OF THE PLAYING AREA, SCALE, ENVIRONMENT AND PLATFORM CHARACTERISTICS OF SEATAG

SEATAG is a manual naval wargame employing two opposing sides Red, Blue, and an umpire Control Group. SEATAG requires three rooms with sufficient desk space for plotting and record keeping, one room for the Control Group and one for each side, Red and Blue. The minimum number of personnel required to play SEATAG is three.

The Control Group performs the umpire functions of intelligence dissemination, detection and damage disclosures and the analysis of interactions during weapons engagements. A Game Director heads the Control Group.

SEATAG comes complete with several grid sheets and cardboard playing pieces to represent force units to be used as the master plot. The grid square scale may vary from

five to thirty nautical miles per grid square side. Locations are coded by a four digit code representing the center of the square and squares can be subdivided into one hundred sub units.

Capabilities of the various platforms are provided on characteristics in Annex C of the SEATAG Rulebook. Characteristics of forty types of modern United States and Soviet ships and aircraft are supplied. The SEATAG data has been taken from editions of Jane's All the Worlds Fighting Ships and from Combat Fleets of the World 1978/1979: Their Ships, Aircraft, and Armament.

SEATAG is limited to two environmental conditions, "good" weather and "bad" weather. One or both may be used in a game. Bad weather effects aircraft and helicopter operations in the same manner and limits all surface units to 15 knots as well. Bad weather degrades sensor performance in terms of range. In addition, each twenty-four hour day is divided into light, from 0600 to 1800, with the remaining 12 hours dark or night. The only effect of dark is to prohibit visual sightings, and any air operations must be made by IFR (Instrument Flight Rules) capable aircraft.

Rules of engagements with several options are also included in the SEATAG Rulebook.

A supplemental resource variation is included with hypothetical costs for the units. These costs are useful in determining the relative balance of a given scenario.

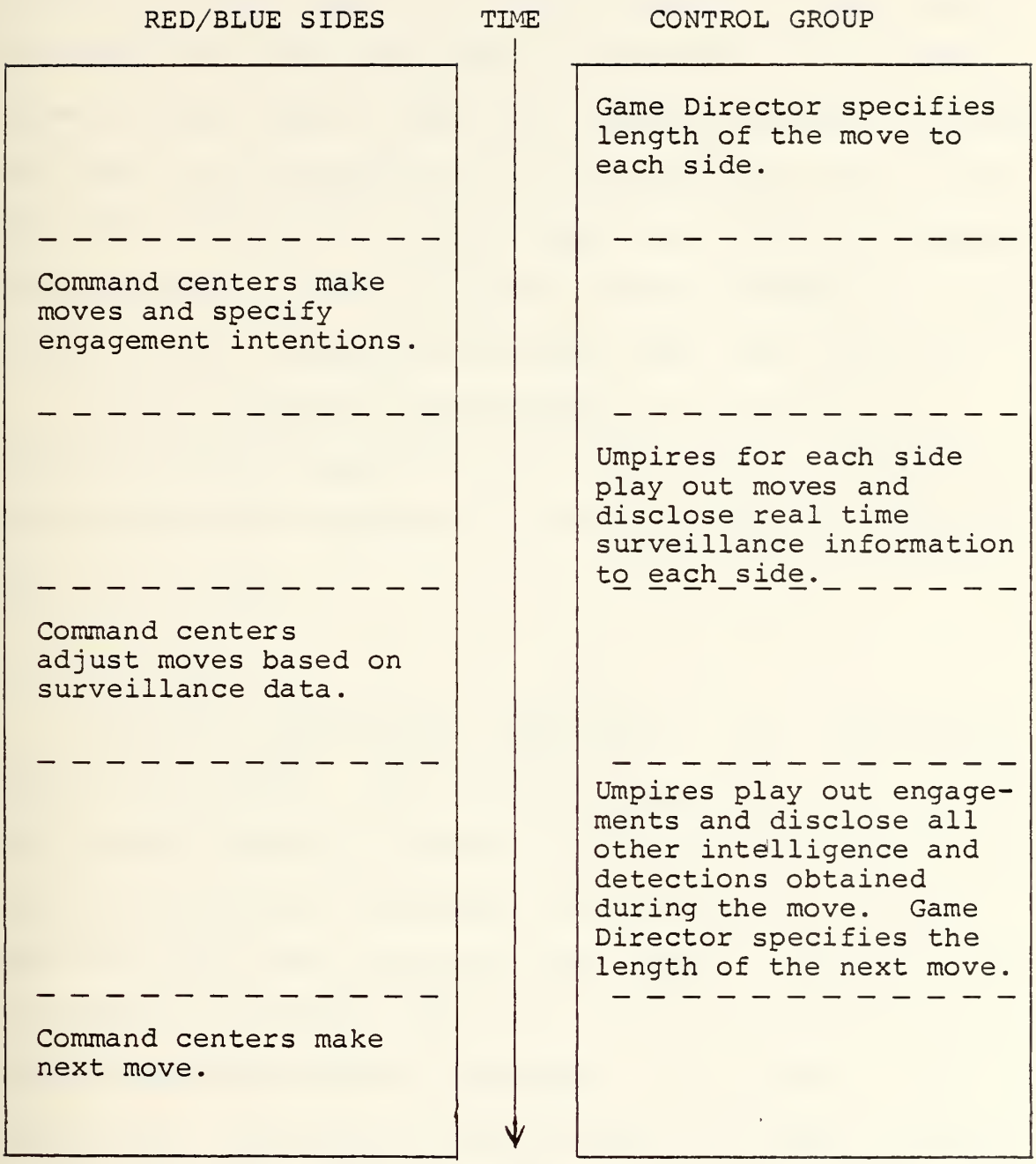
C. GAME FLOW, AIRCRAFT CARRIER AND SUBMARINE OPERATIONS, AND SURVEILLANCE/INTELLIGENCE PLAY

The game flow is graphically depicted in Figure 1.

The initial decision for each turn is the time duration of that turn. This is specified by the umpires who look ahead to see what the engagement intensity is likely to be. The minimum time step is twenty minutes if the smallest grid size is being used. A one hour minimum is specified for the larger grid scales. Red and Blue then make their moves and specify any engagement intentions to the Control Group who then record the moves and disclose any detections to the appropriate sides. The Red and Blue command centers then adjust moves based on this information. Umpires play out the adjusted moves, play engagements, and provide each side with results, additional detections and the time length of the next move. The adjustment phase allows units to respond to detections as they occur rather than wait until the end of the game move.

The SEATAG rules provide a number of tactical hints on ship positioning, task group organization and submarine warfare. In addition a CV operations section provides a simplified but realistic approach to CV cyclical air operations. An around-the-clock defensive posture is provided along with a selection of surge capabilities against various threats.

Surveillance and intelligence has been distilled into three levels. Each side is assigned or allowed to procure Level I, II, or III. At each day of play at times 0001,


RED/BLUE SIDES
TIME
CONTROL GROUP
Game Director specifies length of the move to each side.
Command centers make moves and specify engagement intentions.
Umpires for each side play out moves and disclose real time surveillance information to each side.
Command centers adjust moves based on surveillance data.
Umpires play out engagements and disclose all other intelligence and detections obtained during the move. Game Director specifies the length of the next move.
Command centers make next move.

SEATAG GAME FLOW

Figure 1

0601, 1201, and 1801 a random number is drawn for each surface ship, radiating aircraft and submarine traveling in excess of fiteen knots. In addition another random number is drawn each time a unit uses HF equipment. The number drawn in both cases is used with supplied tables to determine the level of information to be provided to the other side. The level ranges from location information only to complete identification, course and speed. Units in EMCON are less likely to have information divulged than those radiating.

Civilian ships and aircraft may be included in the scenario and are operated by the Control Group. Merchants are not allowed to operate in a military capacity except as part of a convoy.

D. DETECTIONS

A detection opportunity occurs when a unit comes within range of any sensor. The information provided when a detection occurs consists of bearing only for ESM detections and complete information including course, speed, altitude or depth and grid posit for most other sensors. Sonobuoys are an exception, with the amount of information determined by the RN generated when the detection was processed. Additional information, like ship or aircraft type and other characteristics, is left totally to the discretion of the umpires.

E. PLAY OF ENGAGEMENTS AND CALCULATION OF DAMAGE

In SEATAG, engagement analysis is segregated into unit versus unit interactions which are treated in a logical order

determined by when they take place. The Control Group is responsible for this function. The Control Group includes a Red and a Blue chief umpire responsible for playing the engagements for their "side", including tactical decisions as required within the framework of specific operation orders or rules of engagement.

Tables and curves are provided to calculate required information such as targeting, weapon expenditures and number of hits inflicted on a target.

F. TIME UTILIZATION AND SOME OBSERVATIONS ON ACTUAL MANUAL PLAY

SEATAG documentation states that 30 to 60 minutes will be required for the Control Group to process each move or turn. Most likely, 80% of that time is spent plotting and doing movement and Closest Point of Approach (CPA) calculations. However, engagement analysis, once the CPA calculation is made, is relatively straightforward and quick.

III. THE CASTAG PROGRAM

A. OVERALL PROGRAM OPERATION

CASTAG consists of the CASTAG EXEC and three FORTRAN programs - SEARCH, CHANGE, and UPDATE. CASTAG EXEC executes the FORTRAN programs in the specified order. SEARCH processes the input, movement, detection and output functions for one game turn. CHANGE provides the user the option to change any unit parameters prior to the next game move. UPDATE combines each terminal's inputs into an updated data base ready for the next game move.

Prior to execution, each terminal must have access to a disk containing a compiled version of the three FORTRAN programs and the CASTAG EXEC program. In addition, one terminal must have access to the data base.

Figure 2 provides an overall program flowchart showing terminal interaction, file management, and input/output.

1. Overview of CASTAG Inputs

CASTAG inputs can be considered in two groups. First is the data base created by the Control Group. The data base is discussed in Section D of this chapter. Second is the terminal inputs required by CASTAG EXEC, SEARCH, and CHANGE. The program functions associated with these inputs are discussed in this chapter under the appropriate program. Chapter IV discusses these same inputs from the point of view of user data entry and as game parameters.

RED TERMINAL	RED EXEC Routine	BLUE EXEC	BLUE TERMINAL
Enter Blue user ID	READ Blue ID	READ Red ID	Enter Red user ID
Enter "T" to transfer data base**	Transfer file FT02F001 to Blue	READ File FT02F001 from Red	Enter "R" to read data base
Enter inputs for program SEARCH	Execute SEARCH which creates file FT02F001	Execute SEARCH which creates file FT02F001	Enter Inputs for program SEARCH
	Offline print file FT02F001	Offline print file FT02F001	
Enter inputs for Program CHANGE	Execute CHANGE	Execute CHANGE	Enter inputs for Program CHANGE
Enter "R" for Red	Transfer file FT03F001 to Blue	Transfer file FT04F001 to Red	Enter "B" for Blue
Enter "Y" when file ready to be read	Read file FT04F001 from Blue	Read File FT03F001 from Blue	Enter "Y" when file ready to be read
	Execute UPDATE Rewind FT03, FT04	Execute UPDATE Rewind FT03, FT04	
Enter "N" to stop, "Y" to play another game turn	READ "Y" or "N"	READ "Y" or "N"	Enter "Y" to play another game turn, "N" to stop
STOP	STOP	STOP	STOP

**Transfer may occur the other way or not at all if both sides have the data base on file.

OVERALL CASTAG PROGRAM FLOW

Figure 2

2. Dual Terminal Operation

Two terminal operation can only be accomplished by each terminal accessing and executing identical programs in tandem. The programs are designated Red or Blue by an input at the terminal. At the NPS computer center this is the only manner in which this kind of a two sided game can be played.

3. Description of the CASTAG EXEC Routine

CASTAG EXEC executes the three compiled FORTRAN programs and manages the file transfers between terminals.

The CASTAG program begins with a one time interactive sequence in which the User Identification number of the other player is input to identify the other terminal for data transfers.

If required, the data base is transferred to the terminal without it.

The program CHANGE is then executed at each terminal by CASTAG EXEC. CHANGE processes changes entered by the user to a unique data file containing the Red or Blue part of the data base at each terminal. Following an entry to identify the terminal as Red or Blue, an interactive sequence at each terminal manages the cross transfer of these two data files so each terminal has the same information. The UPDATE program is then executed resulting in each terminal having a new but identical data base. Finally, the user is given the option to play another turn or stop.

B. SELECTION OF THE PROGRAMMING LANGUAGES

FORTRAN IV (G) was selected as the programming language for CASTAG because it is a widely used and standardized language. The choice of FORTRAN allows the utilization of CASTAG on other machines and systems in locations other than NPS.

The CASTAG EXEC routine is written in the Control Program - 67/Cambridge Monitoring System (CP/CMS) EXECUTIVE language. Implementation of CASTAG on another computer system not using CP/CMS would require reprogramming in that system's file handling language.

C. FILE SPACE AND CPU TIME REQUIREMENTS OF THE CASTAG PROGRAM

CASTAG uses approximately 186k bytes or 233 records of disk storage. This requirement is compatible with the normal two cylinders of disk space assigned to a user at the NPS Computer Center.

Table 1 lists the program and data files and record lengths which make up the CASTAG program. The source code (FORTRAN) versions are listed for reference but are not required to remain on the disk once compiled. They are not included in the total space requirement.

The largest of the three is SEARCH which takes 40 seconds to compile and from 10 to 12 seconds of CPU time to execute. UPDATE and CHANGE run very vast. The time they take is dependent on the number of user inputs.

Table 1

Cylinder Space Requirements for CASTAG

FILE NAME	FILE TYPE	NO. RECORDS (20 units/side)	NO. RECORDS (50 units/side)
CASTAG	EXEC	9	9
SEARCH	FORTRAN	77	77
SEARCH	TEXT	63	63
UPDATE	FORTRAN	4	4
UPDATE	TEXT	4	4
CHANGE	FORTRAN	10	10
CHANGE	TEXT	8	8
FILE	FT01F001	10	125
FILE	FT02F001	5	12
FILE	FT03F001	3	6
FILE	FT04F001	3	6

D. CREATION AND ORGANIZATION OF THE DATA BASE

The data base contains current game time, the total number of units on each side, and all the parameters for every unit in the game. The data base stores the information from turn to turn to provide game continuity.

The data base is created prior to the start of the game using CP/CMS input and edit functions and placed on a data file. This file is created by the player and must be labeled "FILE FT02F001". Once CASTAG execution has begun, the data base normally is never accessed or changed by the user throughout the entire game.

1. Information Required for the Data Base

Game start time, number and type of units per side, each unit's initial position, course, and speed are required from the Control Group or Game Director.

Each unit must have a unique four digit identification number assigned during creation of the data base. In addition, each unit is assigned a second identifying number called a type number. Directions for assigning and decoding these type numbers are located in Chapter IV of the thesis.

The rest of theparameters required for each unit are found in Annex C of the SEATAG rulebook. Characteristics of two additional units are included in Appendix A of the thesis.

2. Organization and Format of the Data Base

The first row always contains the current game time in minutes, the number of Red units and the number of Blue

units. Each of the following rows represents one ship, submarine, or aircraft. All Red units are listed first followed by all Blue units. Units are not required to be in any particular order as regards aircraft, ships, or submarines. Each column in a row contains the parameters for a particular unit. Each column's description is provided in Table 2.

The current game time is read from the data base in format F6.0 by the FORTRAN programs. The number of Red units and the number of Blue units is read in format 2I3. All the rest of the data base is read in by row as 15I4. All entries must be right justified. An integer format was selected to facilitate input and output formatting. Table 3 is an example of how a correctly formatted data base appears on file.

The data base shows 6 Red and 6 Blue units. Game time is 420 minutes.

E. PLAYING AREA, TIME AND DISTANCE UNITS

The game area is the positive quadrant of the cartesian plane. A unit's location is expressed as an (,) co-ordinate to the nearest nautical mile. The maximum X or Y value is 9999. Units with an X or Y value greater than 1000 will not be plotted on the output.

Game time is computed to the nearest minute and it is therefore possible to play game turns of as little as one minute in duration. Speeds are computed to the nearest whole knot.

TABLE 2

Data Base Column Descriptions

ARRAY COLUMN	FIELD	DESCRIPTION
1	1-4	Unit Identification number. Each unit in the game must have a unique 1 to 4 digit unit ID. An ID of 0000 is reserved for units not in play. The unit ID is not used by the program except to check if a unit is in play.
2	5-8	Unit's current speed in knots.
3	9-12	Altitude or depth of the unit. Altitude for aircraft is in thousands of feet. Surface units must be at 0. Submarines may be deep (2), shallow (1), or surfaced (0).
4	13-16	Unit's course in degrees true.
5	17-20	X coordinate of the unit in m.m.
6	21-24	Y coordinate of the unit in n.m.
7	25-28	Type identification number. Each digit represents coded information which is tabulated in Table of Chapter IV.
8	29-32	Unit's maximum speed in knots.
9	33-36	Surface search radar maximum range in n.m.
10	37-40	Air search radar maximum range in n.m.
11	41-44	Sonar maximum range in n.m.
12	45-48	Status of surface search radar. 1 = On, 0 = Off.
13	49-52	Status of air search radar. 1 = On, 0 = Off.
14	53-56	Status of sonar. 1 = On, 0 = Off.
15	57-60	Status of HF communication equipment. 1 = On, 0 = Off.

Table 3

Sample Data Base

```
  420.   6   6
   50   30    0 160 563 4511332   34   25 150   10   1   1   1   0
   51   10    0 160 545 4881333   35   20 150   10   0   0   0   0
   52   10    0 160 547 4481346   34   20 150   10   0   0   0   0
   60    7    1 100 546 4701110   30  100   0   30   0   0   0   0
    0    0   20  90 900 5001281  450  200   0    0   1   0   0   1
   71   10    1 225 510 5101293  120   30  30    2   1   0   1   1
 1011   10    1  95 550 4732110   30   10   0   30   0   0   0   0
 1022    2    2  90 537 4762111   34   10   0   30   0   0   0   0
  333   11    0  90 495 4802333   30   20 150    5   0   0   1   0
  444   12    0  90 510 4762321   33   25 150    5   1   1   0   1
  555   17    0  90 521 4912347   27   20 150   14   1   1   0   0
  666   30    0  90 537 4612347   27   20 150   14   1   1   1   0
```

All distances in CASTAG are expressed in nautical miles (n.m.) and all speeds in knots.

F. DESCRIPTION OF FORTRAN PROGRAM SEARCH

SEARCH models the movement and detection elements for one game turn of the manual game. SEARCH is the first program executed by CASTAG EXEC.

SEARCH consists of a main program and ten subroutines. These are:

1. Subroutine MOVE (TIME)
2. Subroutine NUMBER
3. Subroutine DETECT (TIME)
4. Subroutine SPOOK
5. Subroutine ESM (I)
6. Subroutine DETRAD (I)
7. Subroutine ASONAR (I)
8. Subroutine NLPCPA (I, TIME)
9. Subroutine VISUAL (I, ITYPE)
10. Subroutine PSONAR (I, IPLAT)

The main program will be described first followed by the ten subroutines which make up SEARCH. Each of the eleven sections includes a list of local variables used and a plain language flowchart for that subroutine.

SEARCH uses two computer library routines, UTPLOT and LLRANDOM. UTPLOT is a utility plotting routine available in the SSPLIB library at the NPS Computer Center. This routine will plot more than one set of points on a graph with a different symbol for each call.

LLRANDOM is used to deliver arrays of single precision U(0,1) distributed pseudo random numbers at various locations in SEARCH. LLRANDOM is accessed by CALL RANDOM.

SEARCH uses an extensive common block, which is identical for all the subroutines. Many variables and arrays in common are used repeatedly throughout the program. Some are used in every subroutine. Definitions of the variables in the common block are found in Table 4. The arrays, all of which are in the common block, are defined in Table 5. Referring back to these two tables will be necessaary as the information is not repeated in the subroutine description.

1. MAIN Program

The MAIN program dimensions all arrays, initializes variables, zeros out arrays, reads the data base from the file, reads the user's terminal inputs, and either calls subroutine NUMBER or reads the random number file. Following the call to subroutine MOVE, the data base with the new X,Y locations for each unit is read back onto the original file and two new files are created, each with only Red or Blue data. Next, a call to subroutine DETECT calculates all detections for the game turn. Finally, UTPLOT is utilized to output two plots on the offline printer.

The MAIN program is executed by CASTAG EXEC. MAIN calls three subroutines directly: NUMBER, MOVE, and DETECT. This turn's game time is supplied to MOVE and DETECT as an argument. Library routine UTPLOT is called as follows:

```
CALL UTPLOT (XPLOT, YPLOT, NUNIT, R, 1, NGRAPH)
```

Table 4

Description of Variables in the SEARCH Common Block

DTIME	Current game turn's length in minutes
EPS	Used to check for zero in the denominator prior to division. Set to .001.
ID	Tells program whether it is Red of Blue. Also used as third subscript to access the friendly information in array DATA.
IFOE	Third subscript used to access opponents information in array DATA. Set opposite of ID.
ISEED1	Random number generator seed used to determine permanent percentage of maximum detection range.
ISEED 2	Random number seed for numbers generated determining HFDF detections.
ISEED 3	Random number seed for numbers generated to determine intelligence detections.
NRED	Number of Red units. Read from the data base.
NBLUE	Number of Blue units. Read from the data base.
NCOL	Maximum number of columns allowed to be used for information storage in the data base and in array DATA. Set to 15. Maximum allowed by array dimension is 20.
NMAX	Maximum number of units that will have random numbers generated for them. Set to 20. Maximum allowed by array dimension is 50.
NWRITE	Used to designate the off-line printer as the output device for a FORTRAN WRITE statement. Set to 6.
ZTIME	Current culmulative game time in minutes. First number read from data base.

Table 5

DEFINITIONS OF ARRAYS IN SEARCH COMMON BLOCK

CPA (50, 2) — Read array holding calculated ranges in column 1 and bearings in column 2 of CPA's for up to 50 units

DATA (50, 20, 2) — Integer array in which the 2nd and subsequent lines of the data base are stored in. Each row holds the information for one unit, usually subscripted by I. The Jth column holds the Jth parameter for the Ith unit. The columns have the same meaning as in the data base. The K = 1 level is all the Red units' data. The K = 2 level is all the Blue units' data. Note that only 15 of the 20 available spaces for unit data are used.

DICE (50) — Real array used to hold up to fifty U(0,1) random numbers from a call to LLRANDOM.

ESMDET (100, 5) — Integer array holding ESM detection data. Each row holds all the information for a single detection. Columns one through five are interpreted as follows:

Column	Info
1	Type of radar detected
2	Bearing of that radar at CPA
3	2nd and 3rd digits of type number of the detected unit
4	Unit ID of emitting unit
5	Range of CPA of detected radar

HFDF (50, 4) — Integer array holding HFDF detection data. Each holds all the information for a single detection of a unit. Columns one through four are interpreted as follows:

Column	Info
1	Unit ID of detected unit
2	Type number of detected unit
3	X coordinate of detected unit
4	Y coordinate of detected unit

Table 5 (Continued)

INTEL (50, 6) — Integer array holding data revealed during an intelligence segment. Each row contains all the information on a single detected unit. Columns one through six are interpreted as follows:

Column	Info
1	Unit ID of detected unit
2	First two digits of type number of detected unit
3	Second two digits of type number of detected unit
4	Course of unit detected to nearest 10 degrees
5	X coordinate of unit detected
6	Y coordinate of unit detected

MINDEX (10) — Integer array. First nine locations not used. MINDEX (10) holds the total number of detected units that will be plotted.

NROW (2) — Integer array holding number of units on each side. Set to NROW (1) = NRED, NROW (2) = NBLUE

PRMAX (50, 50, 5) — Real array holding the calculated permanent percentage of maximum detection range for each sensor of each unit against every enemy unit. With (I,J,K) as the subscripts, the number represents the Kth sensor on the Ith unit trying to detect the Jth enemy unit. The Kth sensor are:

K	Sensor
1	Surface search radar
2	Air search radar
3	ESM
4	Active sonar
5	Passive sonar and passive sonar ESM

R (4) — Real array holding the grid limits of the X and Y values for the plotting routines.

R(1) = 1000.0 Maximum X
R(2) = 0.0 Minimum X
R(3) = 1000.0 Maximum X
R(4) = 0.0 Minimum Y

Table 5 (Continued)

RADAR (50, 20) Integer array holding all radar and visual detection data. The first ten columns are used for radar data, the second ten for visual data. Each half row represents the detection of a unit. The columns are interpreted as follows:

Column	Radar	Column	Visual
1	Unit ID	11	Unit type number
2	Unit type number	12	Unit altitude
3	Radar type (air/surf)	13	Course in deg T
4	Course (T)	14	X coord
5	X coord	15	Y coord
6	Y coord	16	Bearing at CPA
7	Speed	17	Composition
8	Target composition	18	Range at CPA
9	Range at CPA	19	Unit ID
10	Bearing at CPA	20	Not used

SONAR (50, 20) Integer array holding active sonar, passive sonar, and sonar ESM detection data. The first ten columns are used for active detections and the second ten for passive and ESM detections. Each half row represents the detection of a unit. Columns used as follows:

Column	Active	Column	Passive
1	Unit ID	11	Unit ID
2	Unit type	12	Target type number
3	Unit depth	13	Unit depth
4	Unit course	14	Unit course
5	X coord	15	X coord
6	Y coord	16	Y coord
7	Unit speed	17	Unit speed
8	Range at CPA	18	Range at CPA
9	Bearing at CPA	19	Bearing at CPA
10	Not used	20	Not used

XPLOT (50) Real arrays holding the X coordinates of units to be plotted by UTPLOT.

YPLOT (50) Real arrays holding the Y coordinates of units to be plotted by UTPLOT.

XPLOT and YPLOT are explained in Table 5. R and NUNIT are explained in the local variable definitions. The fifth parameter, 1, tells the routine to plot every (X,Y) point. NGRAPH can equal 1, 2, or 3 indicating if this is the first (1), last (3), or an intermediate (2) set of points to be plotted on a graph.

MAIN reads all the data from disk files required by SEARCH except for three user supplied terminal inputs. These are a random number seed, the length in minutes of the current game turn, and whether the terminal is Red or Blue. These are discussed in Chapter IV. However, the turn length and game time control some additional program functions not apparent to the user.

The program expects to begin the first turn at time 0000. In order to generate the initial PRMAX array either ZTIME must be zero or the turn length (TIME) must be zero. Consequently, to start at an initial game time other than 0000, the length of the first turn must be input as zero. Note that in this case no movement or detections are carried out; only the random numbers are generated by NUMBER. Any time a game turn of zero minutes is played, the only effect is to regenerate the PRMAX array with different values.

Table 6 lists the local variables in this routine. Figure 3 is a flowchart of this routine.

Table 6

MAIN Program, Local Variables

DISK Designate which of four files will input or output for a READ or WRITE statement as defined below:

Variable	Value	File Type	Purpose
IDISK	1	FT01F001	Stores DRMAX array
NDISK	2	FT02F001	Stores ZTIME, NRED, NBLUE and DATA array
RDISK	3	FT03F001	Stores Red part of DATA array
BDISK	4	FT04F001	Stores Blue part of DATA array

IMIN Number of minutes into latest hour played thus far.

KSEED Random number seed entered by user.

KTIME Calculated number of hours played thus far.

M Number of opposing units detected that are to be plotted on the first plot.

NGRAPH Parameter for plotting routine designating number of sets of points on that particular plot.

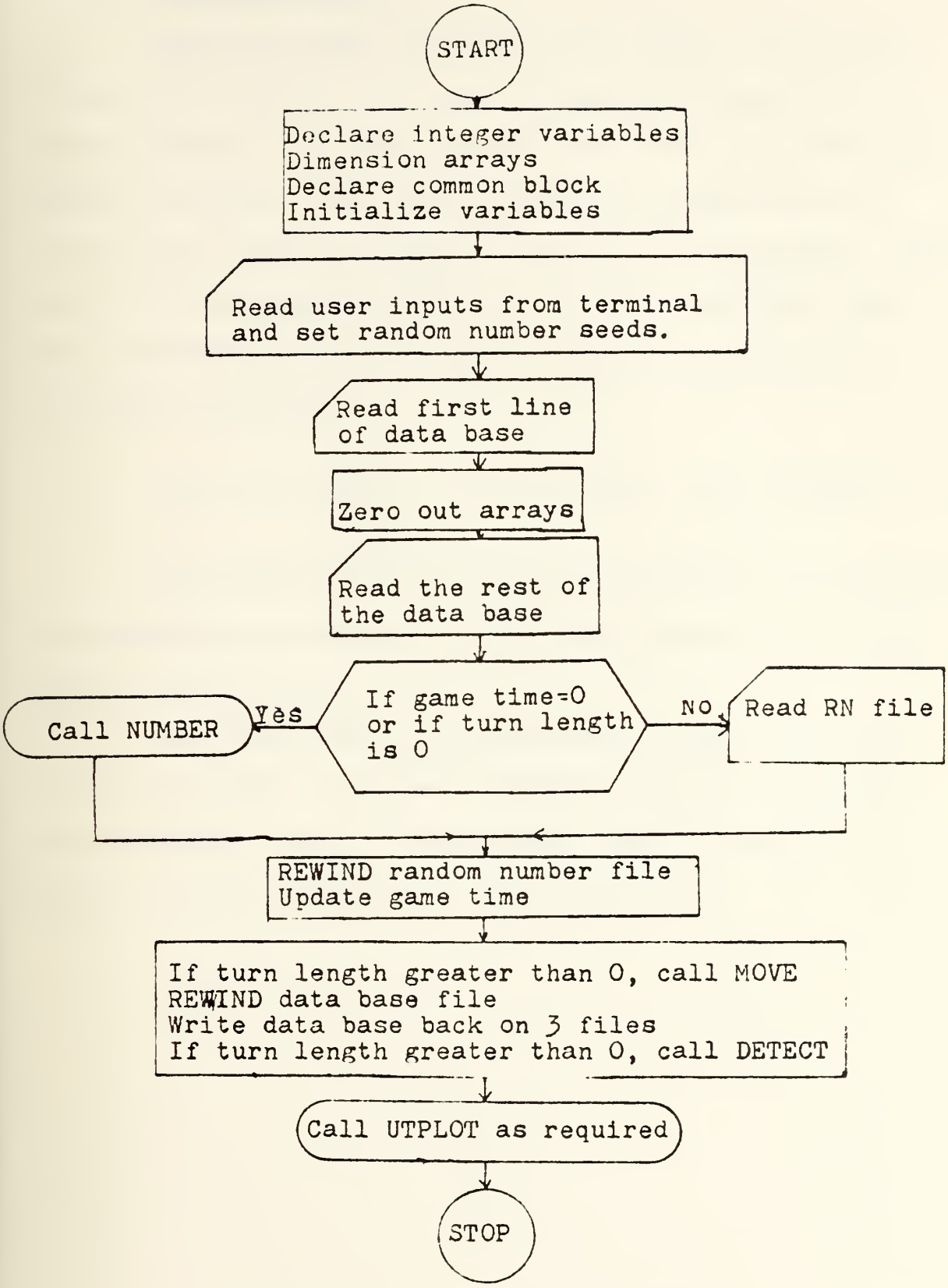
NREAD Input device for FORTRAN READ statement. Set to 5.

NSHIP Maximum number of units arrays can hold. Set to 50.

NTERM Output device for FORTRAN WRITE statement. Set to 5.

NUNIT Number of opposing units to be plotted on second plot.

TIME Length of current turn in minutes; entered by user.



Flowchart of SEARCH MAIN Program

Figure 3

2. Subroutine MOVE

Subroutine MOVE calculates new X and Y coordinates for each Red and Blue unit as a function of course and distance traveled. If a unit crosses the X or Y axis from the positive quadrant, the Y or X coordinate respectively is set to zero, keeping the unit in the positive quadrant. Equation (1) shows the calculation of a new X coordinate; the new Y coordinate is calculated in a similar manner using the cosine function.

$$\text{New X} = \text{Old X} + (.5 + \text{Distance} * \sin(\text{course})) \quad (1)$$

One-half is added so that when the value is truncated for storage as an integer, it in effect rounds off to the nearest nautical mile.

Subroutine MOVE is called once per game turn from the MAIN program. The turn's length in minutes is passed as an argument. Table 7 defines the local variables and Figure 4 is the flowchart for this subroutine.

Table 7

Subroutine MOVE, Local Variables

THOUR	Length of the turn in hours.
RAD	Converts degrees to radians. Set to $\pi/180$.
DIST	Distance the Ith unit moved this turn.
THETA-	Course of the Ith unit converted to radians.
I	Subscripts the row (unit) in array DATA.
K	Subscripts array DATA designating Red or Blue.

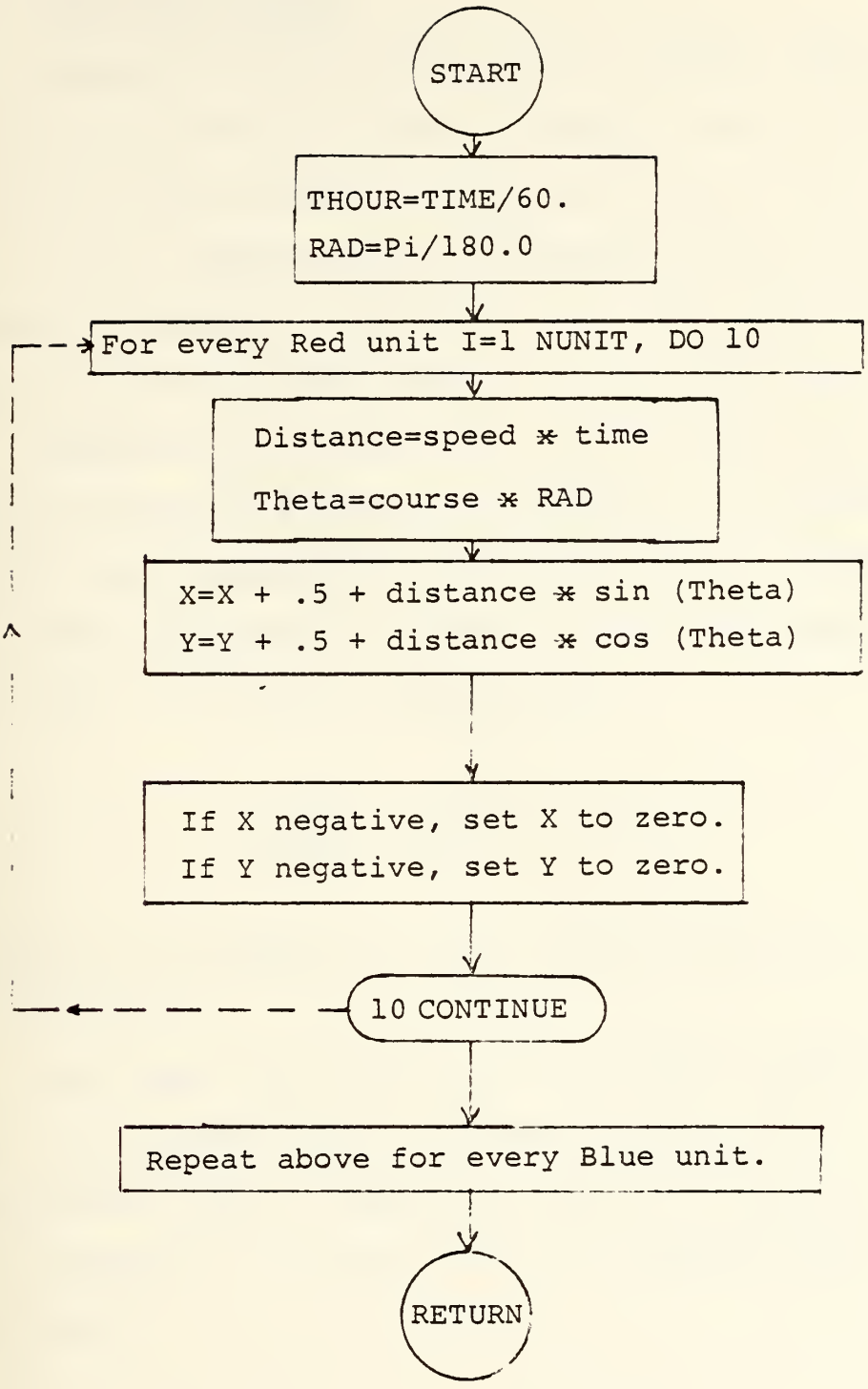

START
THOUR=TIME/60.
RAD=Pi/180.0
For every Red unit I=1 NUNIT, DO 10
Distance=speed * time
Theta=course * RAD
X=X + .5 + distance * sin (Theta)
Y=Y + .5 + distance * cos (Theta)
If X negative, set X to zero.
If Y negative, set Y to zero.
10 CONTINUE
Repeat above for every Blue unit.
RETURN

Figure 4

Flowchart of Subroutine MOVE (TIME)

3. Subroutine NUMBER

Subroutine NUMBER draws a U(0,1) random number and calculates the percent of maximum range at which a detection can occur for every sensor on every unit versus every target unit. A U(0,1) random number is drawn for every possibility, regardless of whether a particular unit has a particular sensor or can ever be detected by a particular sensor.

SEATAG uses an empirically derived curve to manually transform the random number into a percent of maximum range. This curve was approximated by the hyperbola in Equation (1), where X equals the percent of maximum detection range (PRMAX) and Y is a U(0,1) random number.

$$\frac{X^2}{(.9)^2} + \frac{Y^2}{(.9)^2} = 1.0 \qquad (1)$$

The hyperbola is graphed with the original curve for comparison in Figure 5.

Note that the X and Y aixs in Figure 5 have different scales. The maximum error, determined graphically, is 2% of the maximum range. Subroutine NUMBER uses Equation (2) which is Equation (1) solved for X to calculate the actual PRMAX values.

$$X = .81 - Y^2 \qquad (2)$$

Subroutine NUMBER is usually called by MAIN only on the first game turn. Thereafter the calculated values are stored from turn to turn on a file.

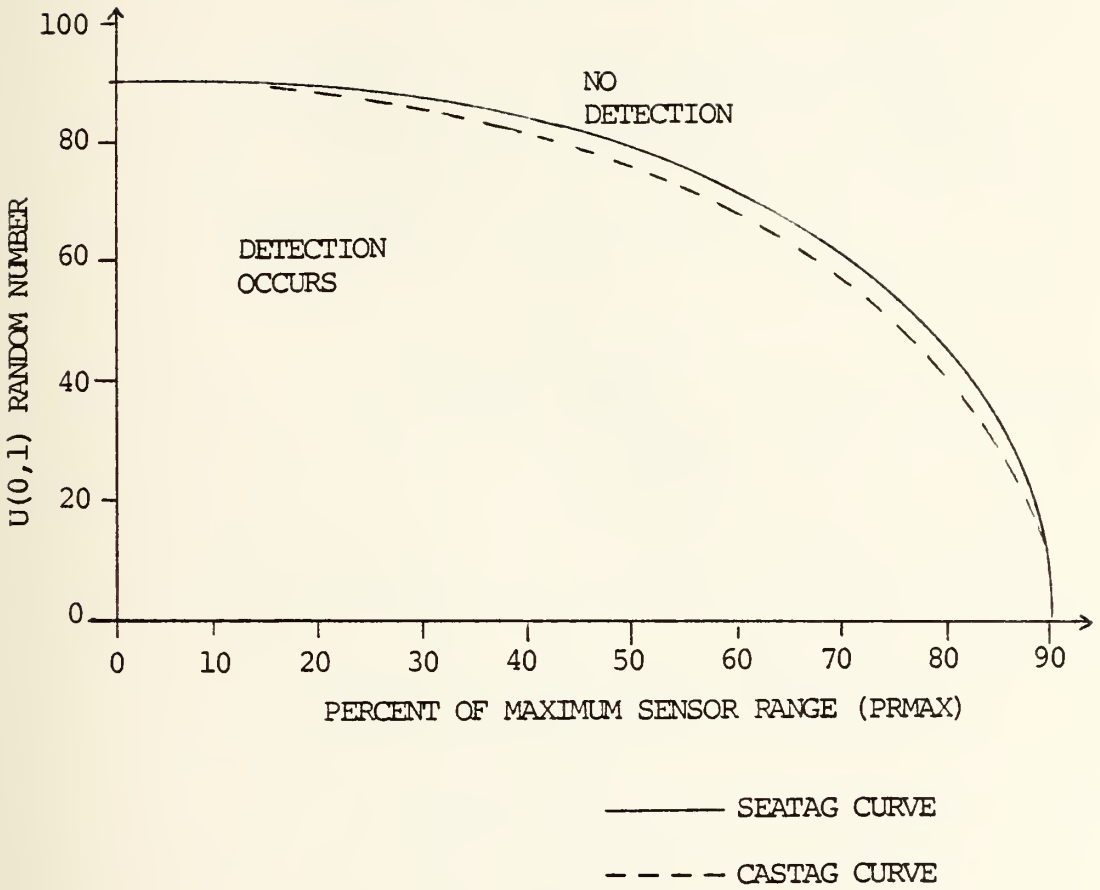


Figure 5

COMPARISON OF DETECTION CURVES

With the exceptions of subscripts I, J, and K, no local variables are used in this subroutine. Figure 6 is the flowchart for subroutine NUMBER.

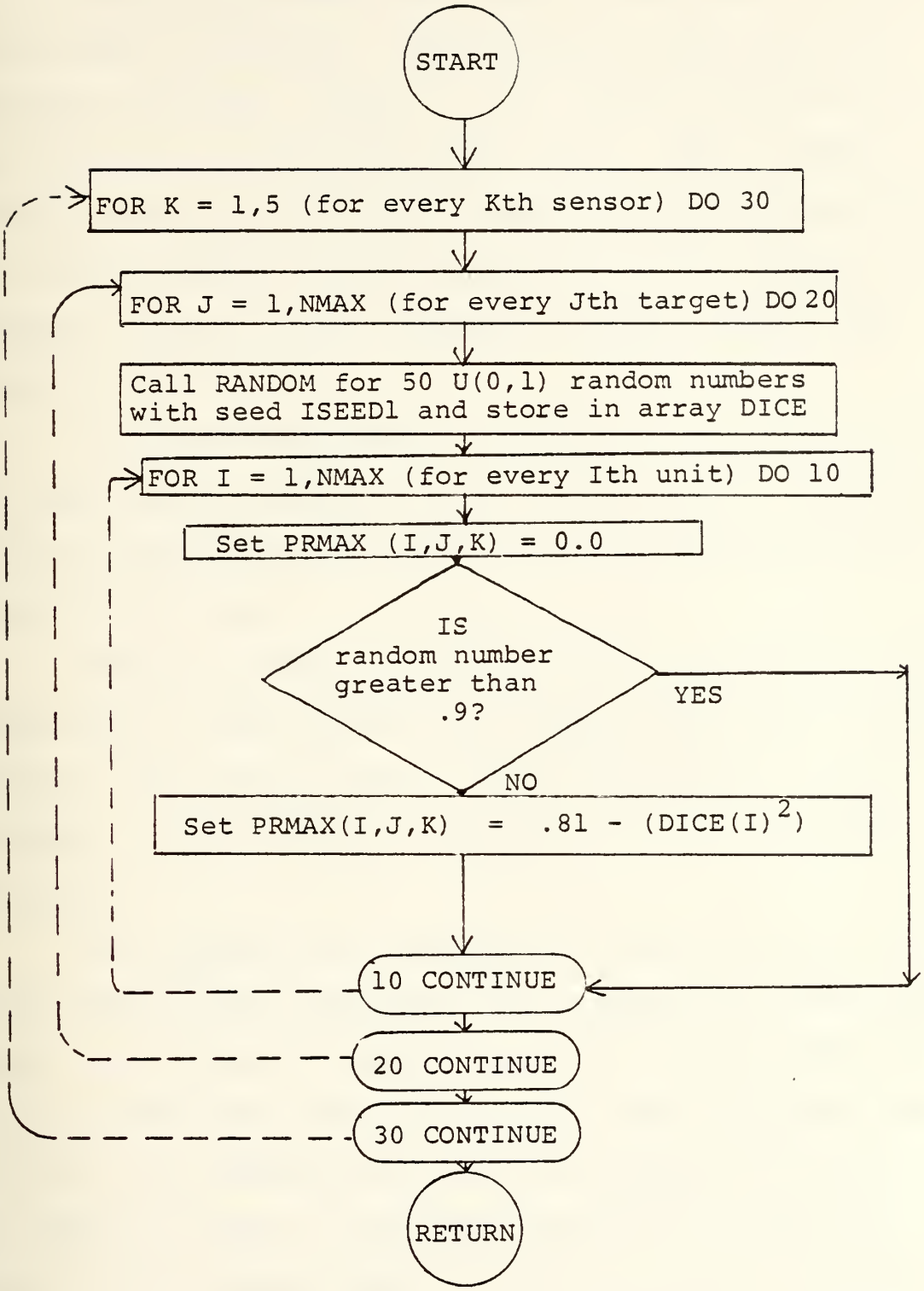

START
FOR K = 1,5 (for every Kth sensor) DO 30
FOR J = 1,NMAX (for every Jth target) DO 20
Call RANDOM for 50 U(0,1) random numbers with seed ISEED1 and store in array DICE
FOR I = 1,NMAX (for every Ith unit) DO 10
Set PRMAX (I,J,K) = 0.0
IS random number greater than .9?
YES
NO
Set PRMAX(I,J,K) = .81 - (DICE(I)2)
10 CONTINUE
20 CONTINUE
30 CONTINUE
RETURN

Figure 6

Flowchart for Subroutine NUMBER

4. Subroutine DETECT

The most important and complex subroutine in SEARCH is the DETECT subroutine. The subroutine comprises three functional sections. First, it must decide if the current turn includes a surveillance opportunity. Next, intelligence from enemy units using HF communication is determined. Last, every eligible friendly unit is given the opportunity to detect eligible targets subject to sensor, speed, and platform limitations.

For HFDF intelligence purposes, the program assumes that each side has procured level I intelligence. Accordingly, the only information provided is the grid position of the enemy unit detected.

DETECT performs the umpire function of deciding which sensors may be used against which targets under what circumstances. Some ground rules for this are implicit in the flowchart and some explicitly explained in the following paragraphs.

The program gives submarines at shallow depth some of the capabilities associated with a submarine at periscope depth. In particular, shallow submarines may make ESM and surface search (S/S) radar detections. This represents the ability of the submarine to extend its ESM and S/S radar mast above the water in the same manner as the periscope. Except for ESM against radar emissions, a shallow submarine is still undetectable by means other than sonar. The program does not allow for visual detection by periscope due to the limited maximum range at which such a detection could occur.

Fighter, strike (attack), interceptors and ECM aircraft may only make visual detections. In general radars on board these aircraft are fire control radars without a 360 degree search capability. Their ESM equipment is primarily short range threat warning oriented and is used to provide a warning of fire control or missile homing acquisition or lock on. Also these aircraft are never detectable by ESM in the program due to the narrow sector of the emitters.

Arbitrary limits of ten knots maximum speed and 1000 feet or less altitude were imposed on the SH-3 and KA-25 helicopters before they may attempt a dipping sonar detection.

Subroutine DETECT is called once per turn from the MAIN program. Subroutine DETECT calls the following subroutines.

1. SPOOK
2. ESM (I)
3. DETRAD (I)
4. ASONAR (I)
5. NLPCPA (I, TIME)
6. VISUAL (I, ITYPE)
7. PSONAR (I, IPLAT)

The I argument passed to all the subroutines called except SPOOK designates the row subscript of the unit searching with that particular sensor.

The second argument passed to NLPCPA is the same length of the current turn passed to DETECT. The second

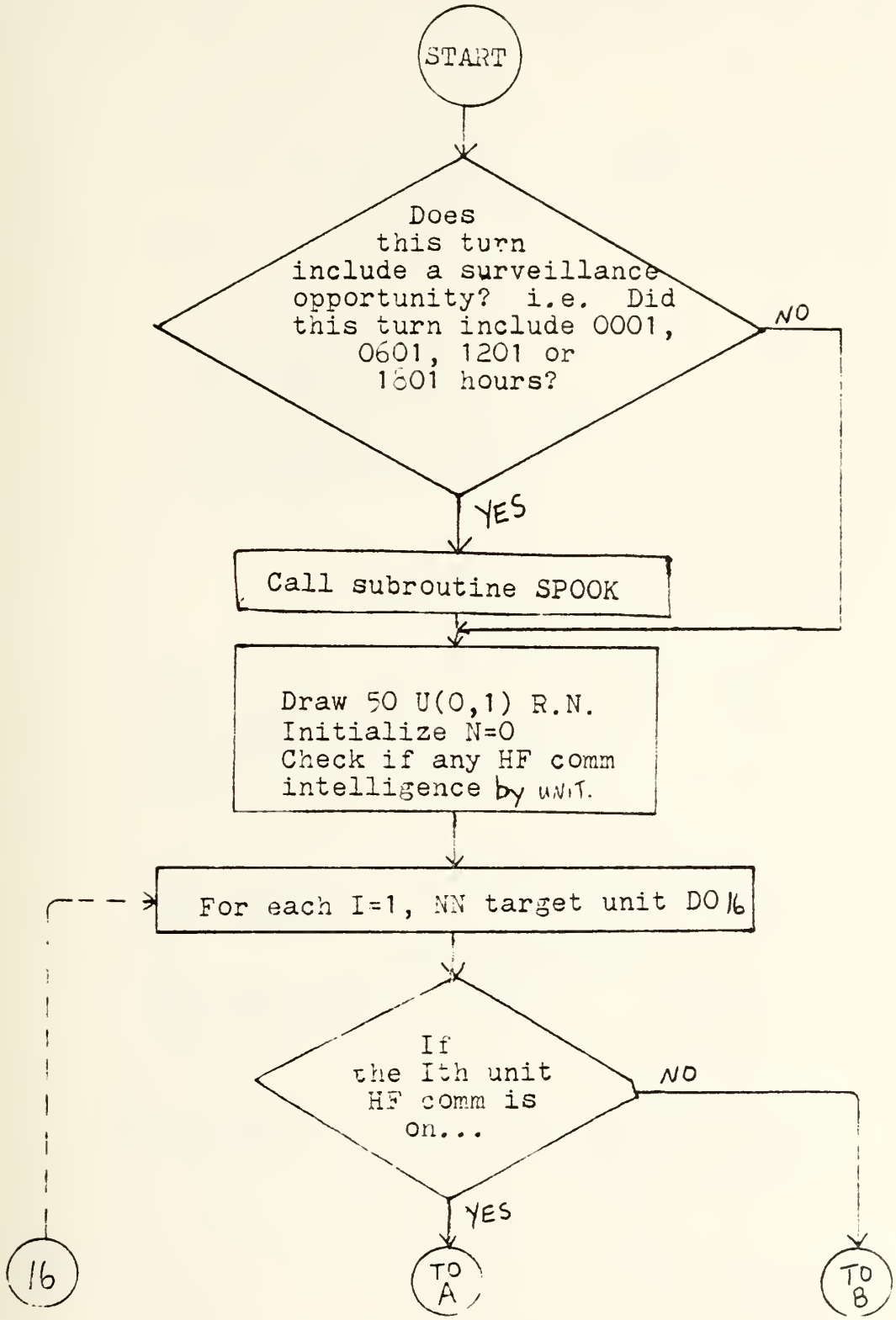
argument passed to VISUAL and PSONAR indicates what kind of unit the Ith unit is.

Table 8 contains the local variables used in DETECT and Figure 7 is a flowchart for DETECT.

Table 8

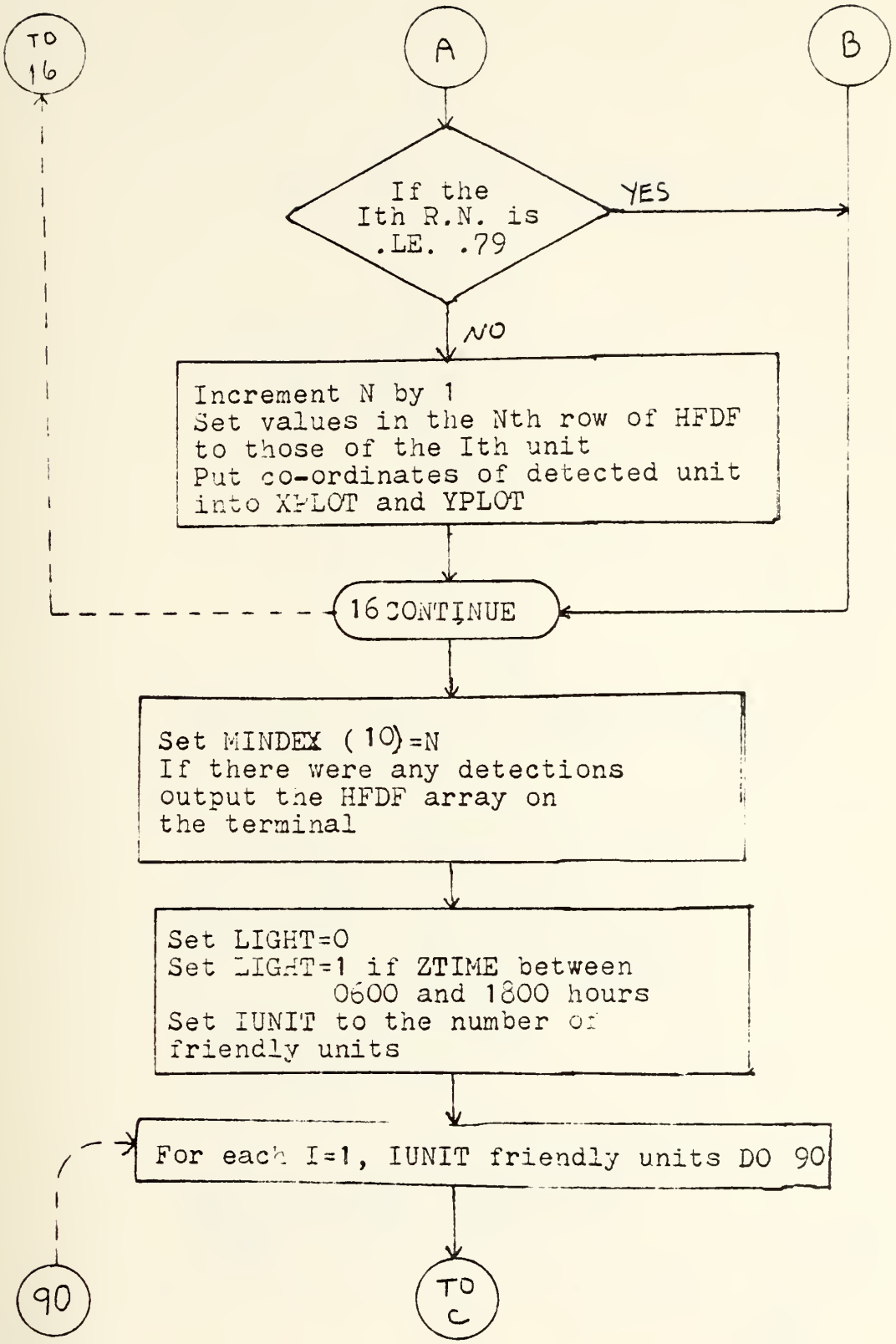
Subroutine DETECT, Local variables

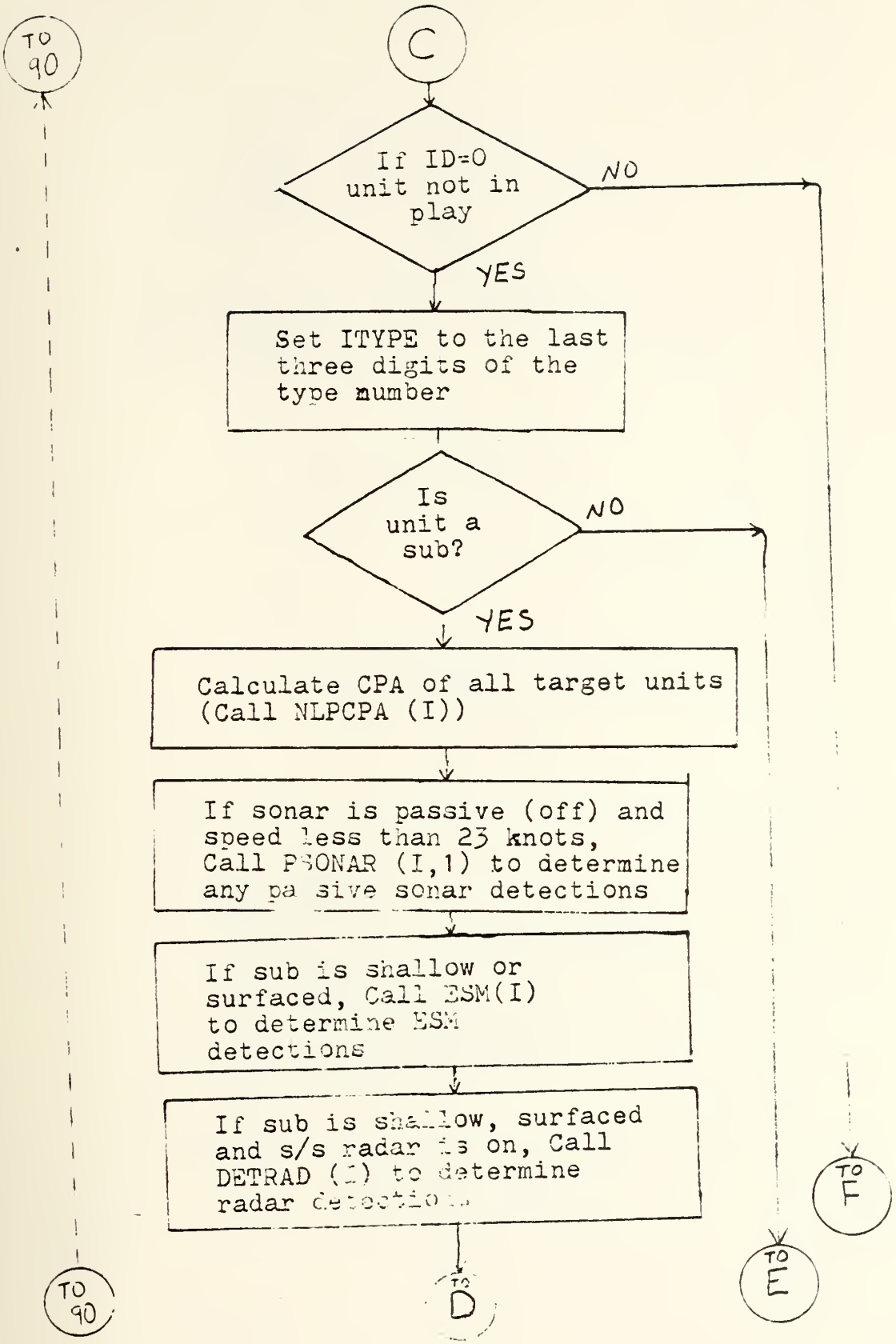
VARIABLE	DESCRIPTION
HR	Counter for six hour surveillance periods.
ITYPE	Last three digits (or last two if an aircraft) of the Ith units type number.
I	Subscript of Ith friendly unit in do loop 90, Ith enemy unit in do loop 16.
IUNIT	Total number of friendly units.
LIGHT	Set by the program to 0 = Dark, 1 = Daylight as a function of game time.
N	Counter for the number of HFDF detections.
NN	Total number of enemy units.
NX	Used in do loop 11 to calculate six hour periods for surveillance periods.
Z2	The time in minutes the previous turn ended.

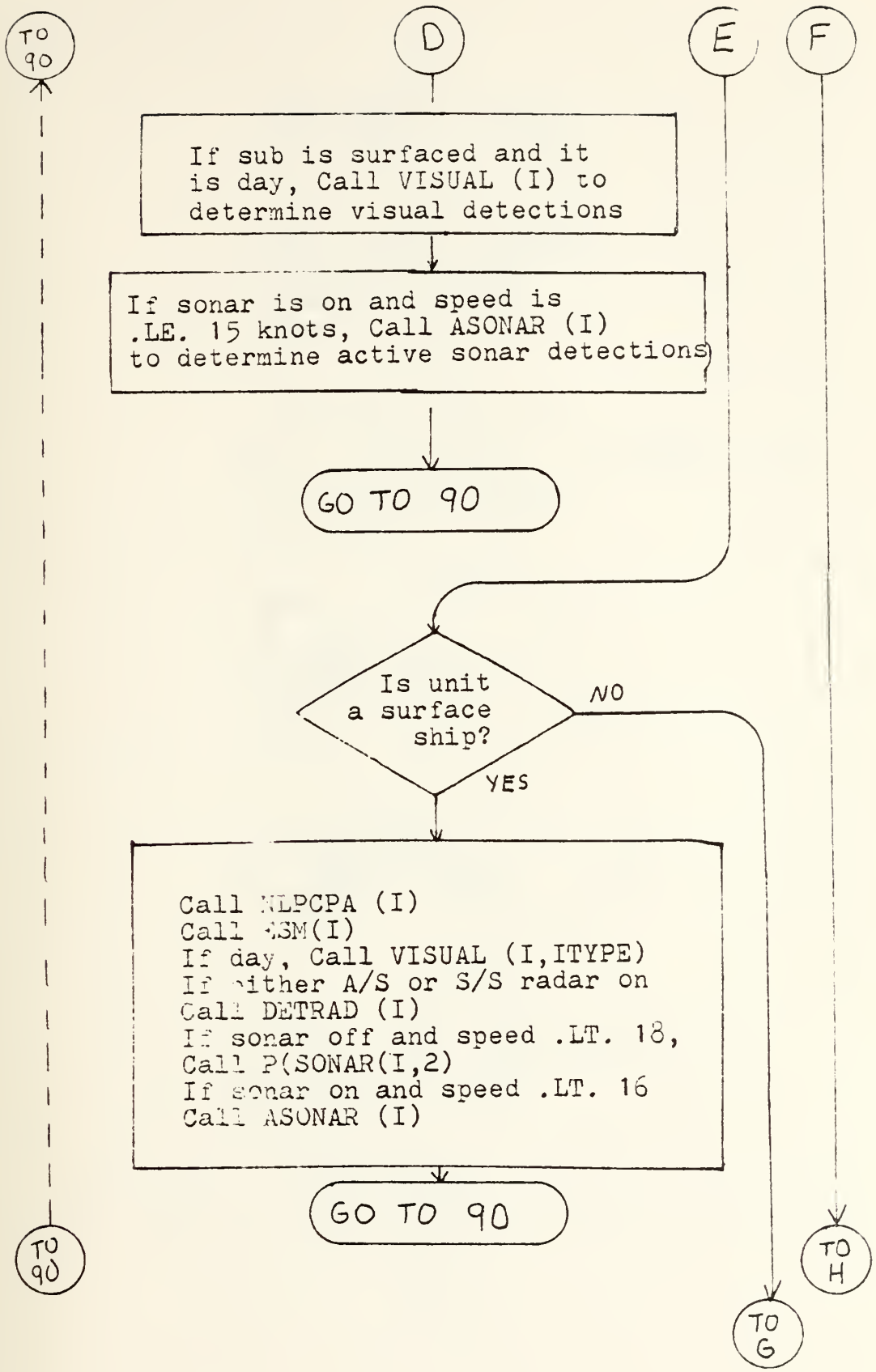

START
Does this turn include a surveillance opportunity? i.e. Did this turn include 0001, 0601, 1201 or 1801 hours?
NO
YES
Call subroutine SPOOK
Draw 50 U(0,1) R.N.
Initialize N=0
Check if any HF comm intelligence by unit.
For each I=1, NN target unit DO 16
If the Ith unit HF comm is on...
NO
YES
16
TO A
TO B

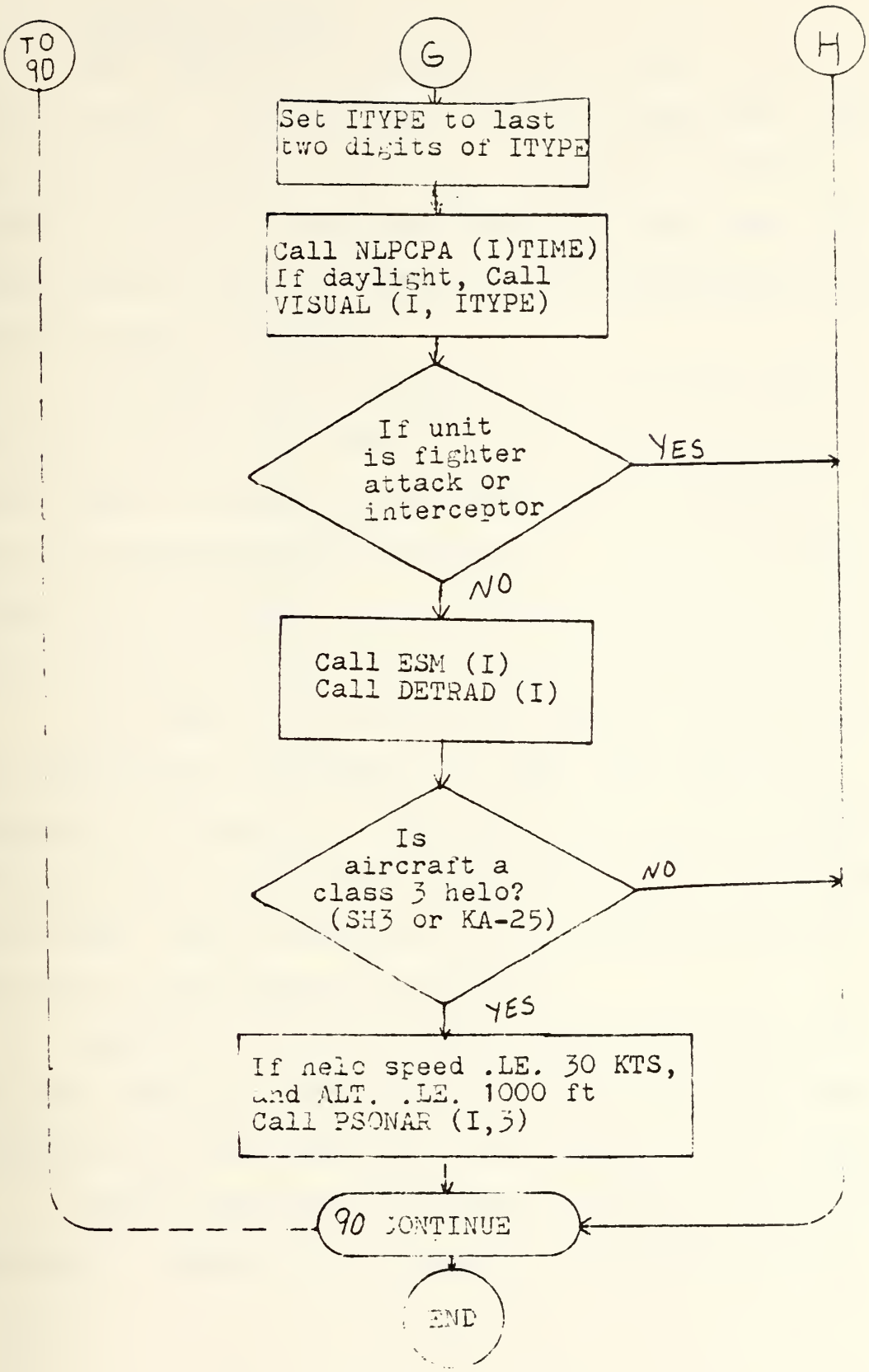
Flowchart of Subroutine DETECT

Figure 7


TO 16
A
B
If the Ith R.N. is .LE. .79
YES
NO
Increment N by 1
Set values in the Nth row of HFDF to those of the Ith unit
Put co-ordinates of detected unit into XPLOT and YPLOT
16 CONTINUE
Set MINDEX (10)=N
If there were any detections output the HFDF array on the terminal
Set LIGHT=0
Set LIGHT=1 if ZTIME between 0600 and 1800 hours
Set IUNIT to the number of friendly units
For each I=1, IUNIT friendly units DO 90
90
TO C


TO 90
C
If ID=0 unit not in play
NO
YES
Set ITYPE to the last three digits of the type number
Is unit a sub?
NO
YES
Calculate CPA of all target units (Call NLPCPA (I))
If sonar is passive (off) and speed less than 23 knots, Call PSONAR (I,1) to determine any passive sonar detections
If sub is shallow or surfaced, Call ESM(I) to determine ESM detections
If sub is shallow, surfaced and s/s radar is on, Call DETRAD (I) to determine radar detections
TO D
TO E
TO F
TO 90


TO 90
D
E
F
If sub is surfaced and it is day, Call VISUAL (I) to determine visual detections
If sonar is on and speed is .LE. 15 knots, Call ASONAR (I) to determine active sonar detections
GO TO 90
Is unit a surface ship?
NO
YES
Call NLPCPA (I)
Call ASM(I)
If day, Call VISUAL (I,ITYPE)
If either A/S or S/S radar on
Call DETRAD (I)
If sonar off and speed .LT. 18,
Call P(SONAR(I,2)
If sonar on and speed .LT. 16
Call ASONAR (I)
GO TO 90
TO 90
TO H
TO G


TO 90
G
H
Set ITYPE to last two digits of ITYPE
Call NLPCPA (I)TIME)
If daylight, Call VISUAL (I, ITYPE)
If unit is fighter attack or interceptor
YES
NO
Call ESM (I)
Call DETRAD (I)
Is aircraft a class 3 helo? (SH3 or KA-25)
NO
YES
If helo speed .LE. 30 KTS, and ALT. .LE. 1000 ft
Call PSONAR (I,3)
90 CONTINUE
END

5. Subroutine SPOOK

This subroutine is played daily at 0001, 0601, 1201, and 1801 hours. In game terms this is an abstracted representation of sources of military intelligence available beyond the level of command represented in the game. The CASTAG program only plays level I of the three surveillance levels available in SEATAG.

All ships, submarines going over 15 knots and radiating aircraft are subject to detection. A U(0,1) random number is drawn for each unit and if that unit is in one of the three preceding categories, it may be detected. If the unit is in EMCON, i.e., emitting no radiation including sonar, the chance of detection is reduced twenty percent.

If a unit is detected, grid location and general/type information is provided. In some cases additional information consisting of the units course to the nearest 10 degrees and the last two digits of the unit's type number is provided. This information is a condensed version of Table II-5 in the SEATAG documentation.

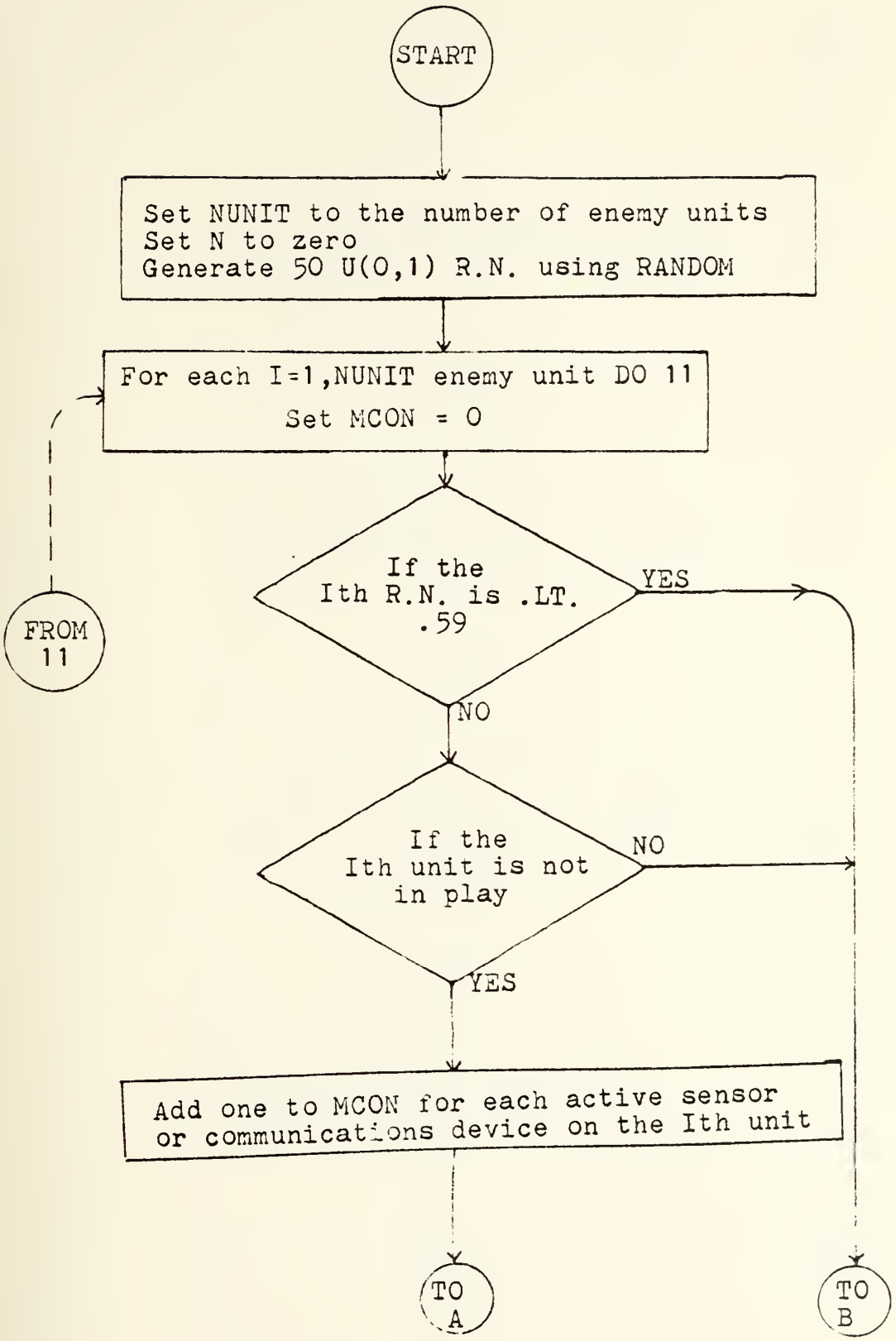
Subroutine SPOOK is called at most once per game turn from subroutine DETECT only if the current game turn included one of the four times that surveillance is played.

Table 9 describes the local variables used in this subroutine. Figure 8 is a flowchart of subroutine SPOOK.

Table 9

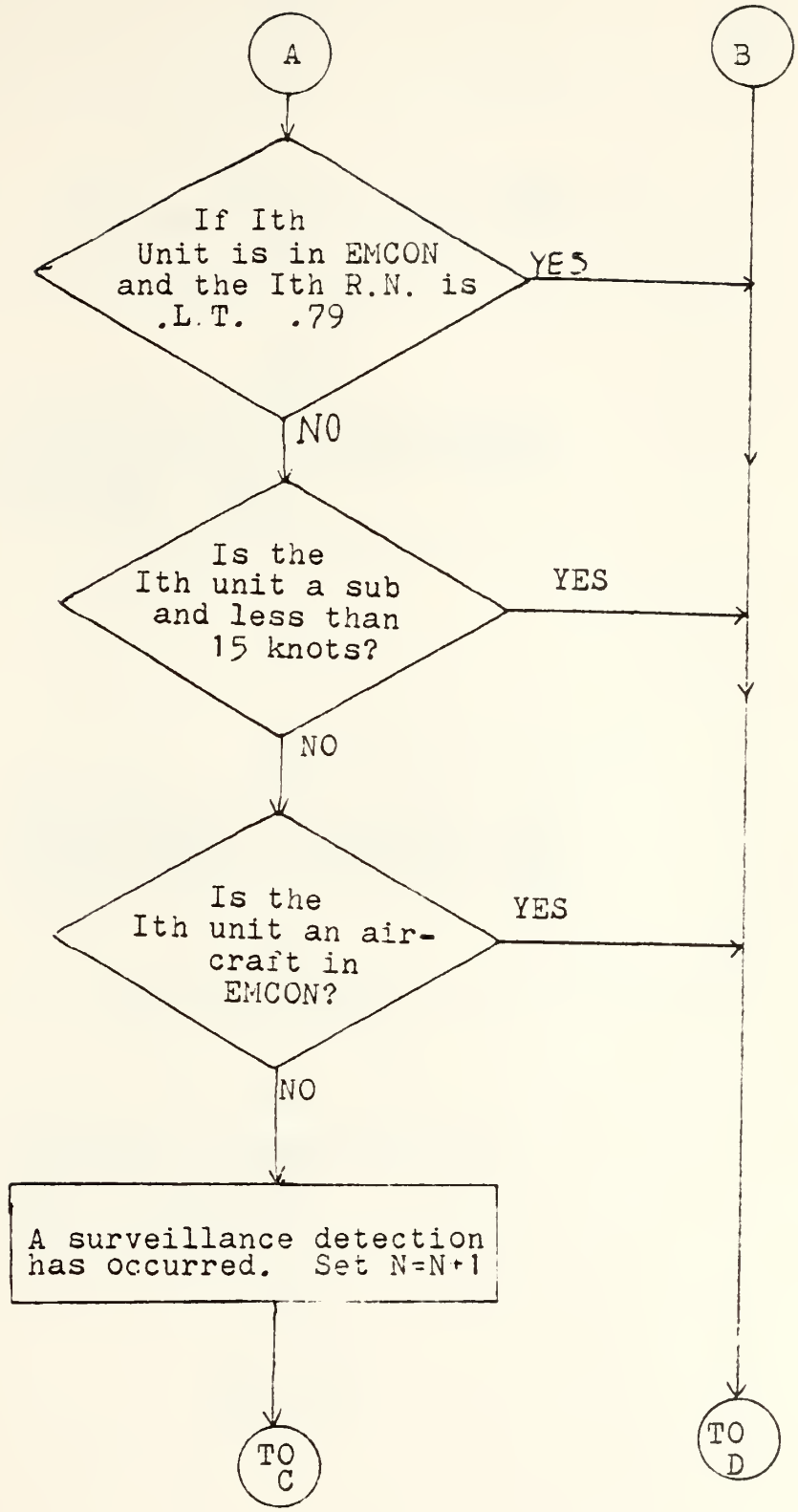
Subroutine SPOOK, Local Variables

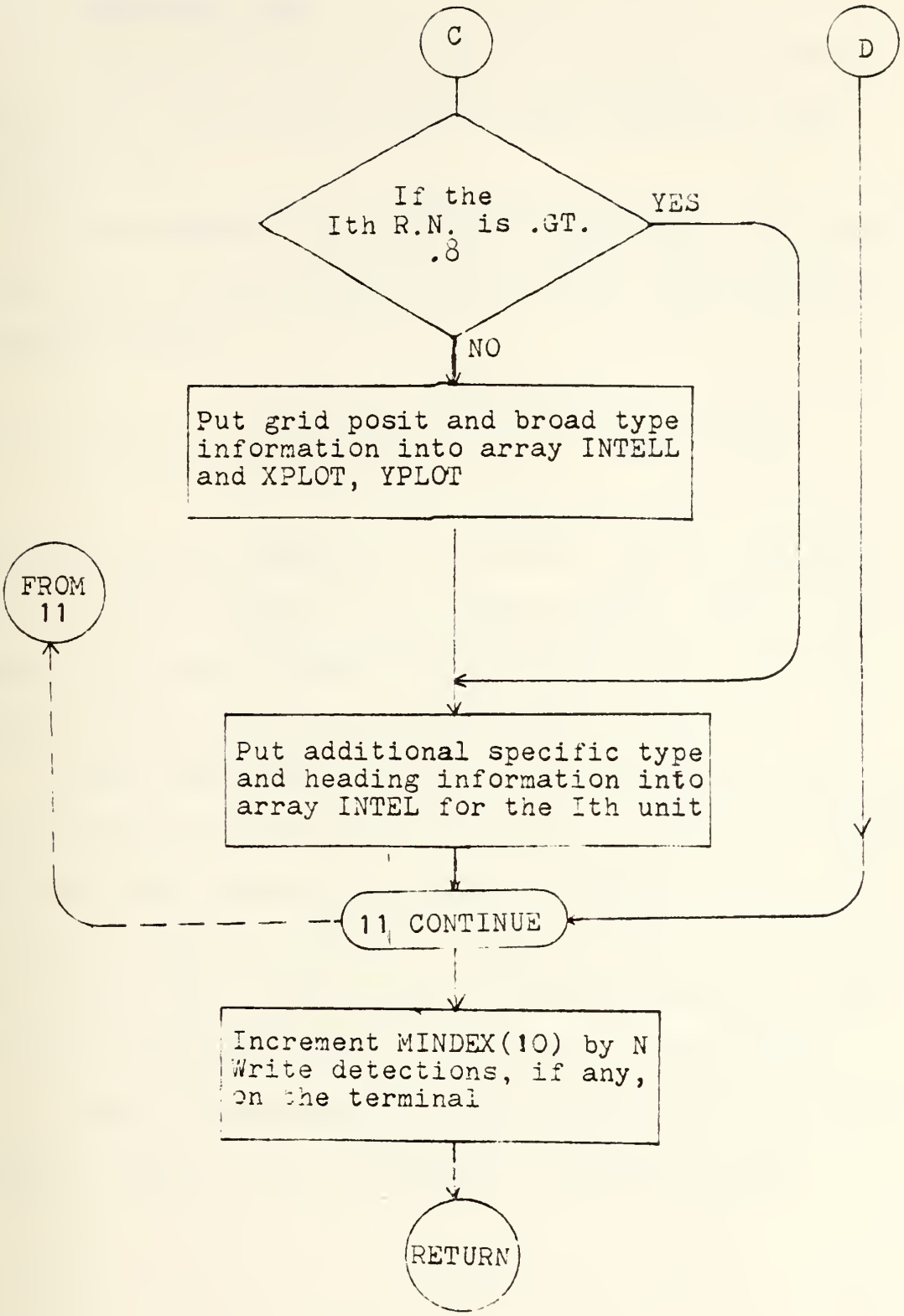
Variable	Description
I	Row subscript of the unit being checked.
ID2	Set to first two digits of the Ith unit's type number.
J	Varying column sbuscript of array DATA in do loop 9.
MCON	Sum of the number of active emitters on a unit. MCON = 0 means unit is in EMCON.
N	Counter for number of surveillance detections.
NUNIT	Set to total number of enemy units.


START
Set NUNIT to the number of enemy units
Set N to zero
Generate 50 U(0,1) R.N. using RANDOM
For each I=1,NUNIT enemy unit DO 11
Set MCON = 0
FROM 11
If the Ith R.N. is .LT. .59
YES
NO
If the Ith unit is not in play
NO
YES
Add one to MCON for each active sensor or communications device on the Ith unit
TO A
TO B

Flowchart of Subroutine SPOOK

Figure 8


A
B
If Ith Unit is in EMCON and the Ith R.N. is .L.T. .79
YES
NO
Is the Ith unit a sub and less than 15 knots?
YES
NO
Is the Ith unit an air-craft in EMCON?
YES
NO
A surveillance detection has occurred. Set N=N+1
TO C
TO D


C
D
If the Ith R.N. is .GT. .8
YES
NO
Put grid posit and broad type information into array INTELL and XPLOT, YPLOT
FROM 11
Put additional specific type and heading information into array INTEL for the Ith unit
11 CONTINUE
Increment MINDEX(10) by N Write detections, if any, on the terminal
RETURN

6. Subroutine ESM

Subroutine ESM determines all possible ESM detections by the Ith friendly unit of radar emissions from each enemy unit.

The maximum range for ESM detections is calculated as twice the maximum range of the emitter times the percent of maximum range:

$$\text{Range} = 2 * \text{PRMAX}(I,N,3) * (\text{Radar Range})$$

The subscripts for PRMAX are I denoting the Ith detecting unit, N the Nth target and 3 the ESM sensor. This is compared to the range of the CPA to determine if a detection occurs. Detections are stored in array ESMDET.

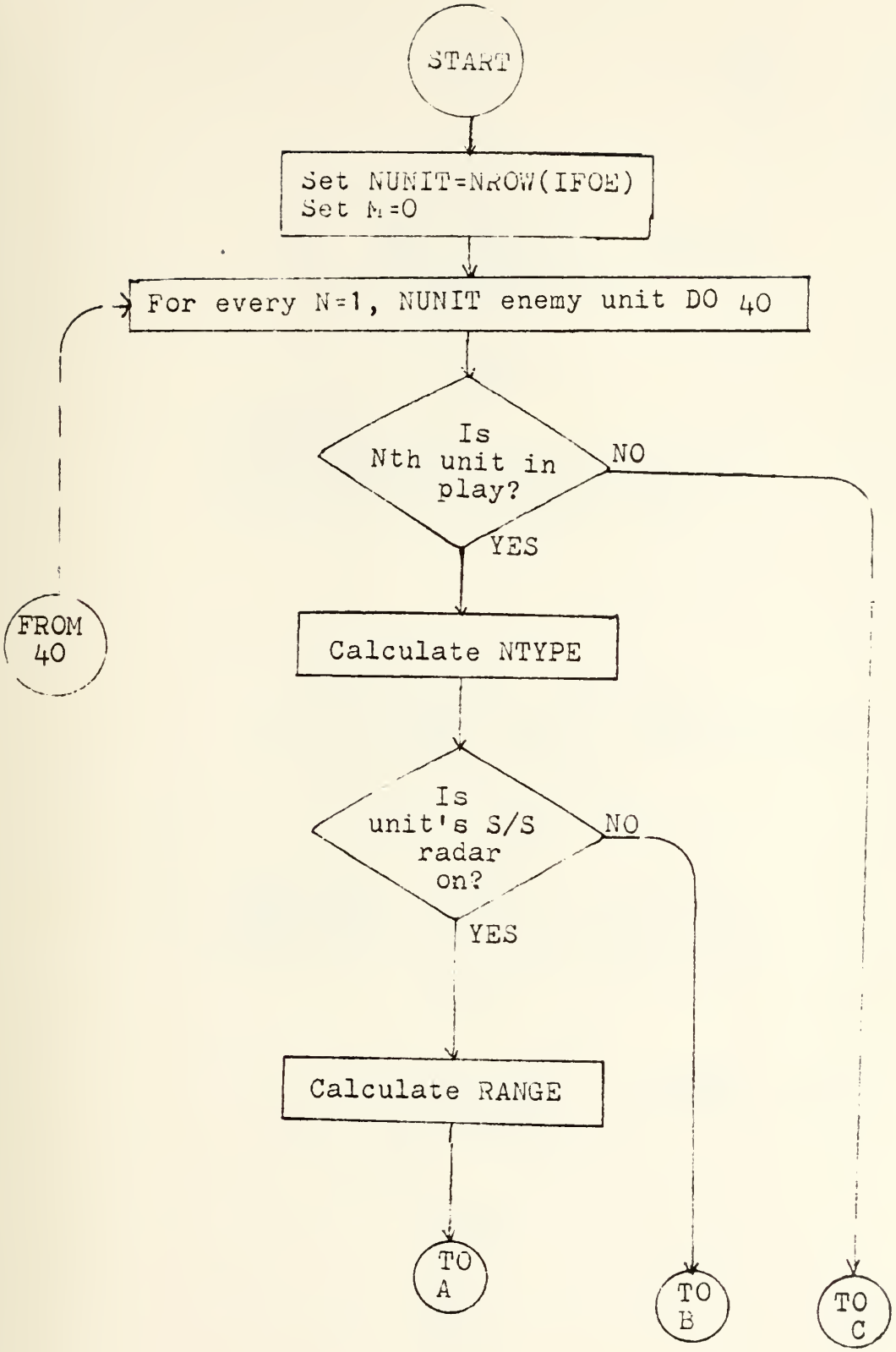
This subroutine is called from DETECT when the Ith unit is eligible to make ESM detections. Subroutine NLPCPA must have been called previously from DETECT so that the range and bearing of the CPA of every enemy unit is available in array CPA. The percent of maximum range for the Ith units ESM system must be available in array PRMAX.

Table 10 contains the local variables used in this routine. Figure 9 is a flowchart of subroutine ESM.

Table 10

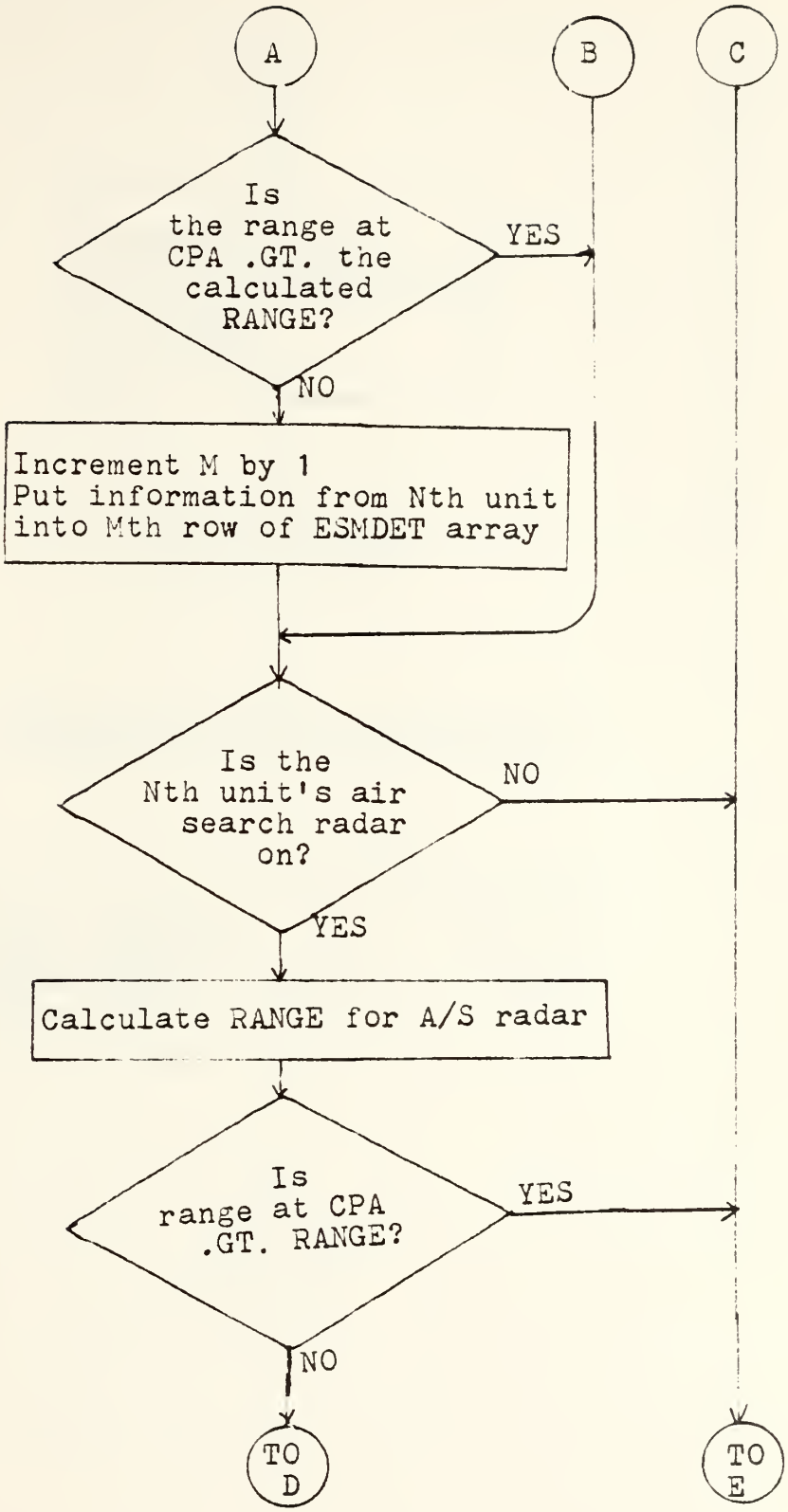
Local Variables of Subroutine ESM

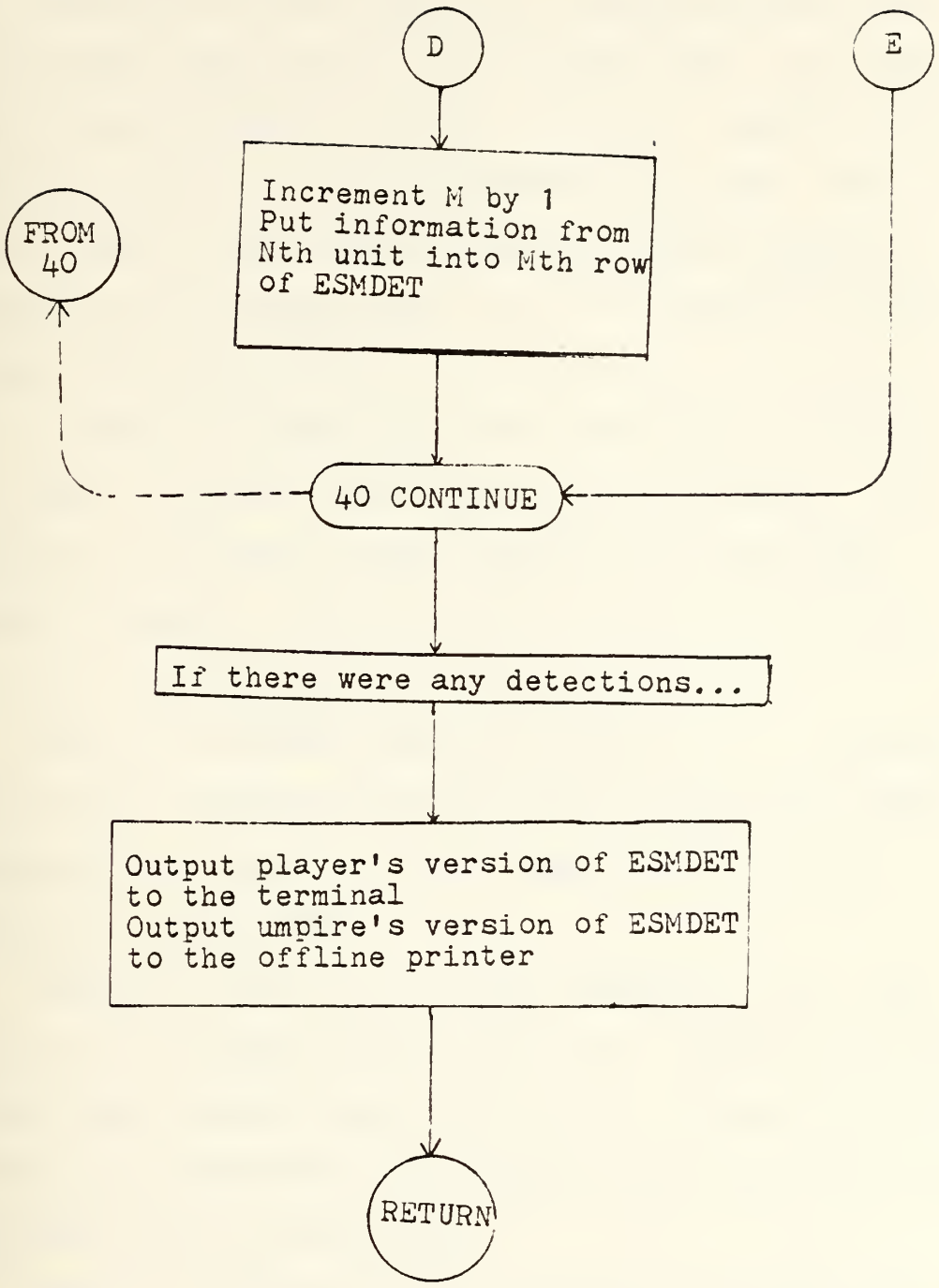
Variable	Description
I	Argument passed from DETECT denoting the Ith friendly unit as the unit attempting to make the detections.
II, JJ	Row and column subscripts for printing out array ESMDET.
M	Counter for number of ESM detections for the Ith unit.
N	Row subscript of DATA denoting the Nth enemy unit.
NTYPE	Last three digits of the Nth unit's type number.
NUNIT	Set to total number of enemy units.
RANGE	Range at which detection may take place.



Flowchart of Subroutine ESM(I)

Figure 9


A
B
C
Is the range at CPA .GT. the calculated RANGE?
YES
NO
Increment M by 1
Put information from Nth unit into Mth row of ESMDET array
Is the Nth unit's air search radar on?
NO
YES
Calculate RANGE for A/S radar
Is range at CPA .GT. RANGE?
YES
NO
TO D
TO E


D
E
Increment M by 1
Put information from
Nth unit into Mth row
of ESMDET
FROM
40
40 CONTINUE
If there were any detections...
Output player's version of ESMDET
to the terminal
Output umpire's version of ESMDET
to the offline printer
RETURN

7. Subroutine DETRAD

Subroutine DETRAD checks all possible radar detections of enemy units for the Ith friendly unit. Air search radars are only allowed to detect aircraft. Surface search radars only detect ships and surfaced submarines. The detection range of both air and surface search radars is calculated as the maximum range times the percent of maximum range from array PRMAX.

A detection takes place when the detection range of the radar is greater than the CPA of the target. For submarines, this range is then halved making them more difficult to detect. Detections are stored sequentially in the first ten columns of integer array RADAR.

The only argument passed to DETRAD is I. I specifies the row of the friendly unit attempting to make the radar detections and is used as the row subscript to access information in array DATA.

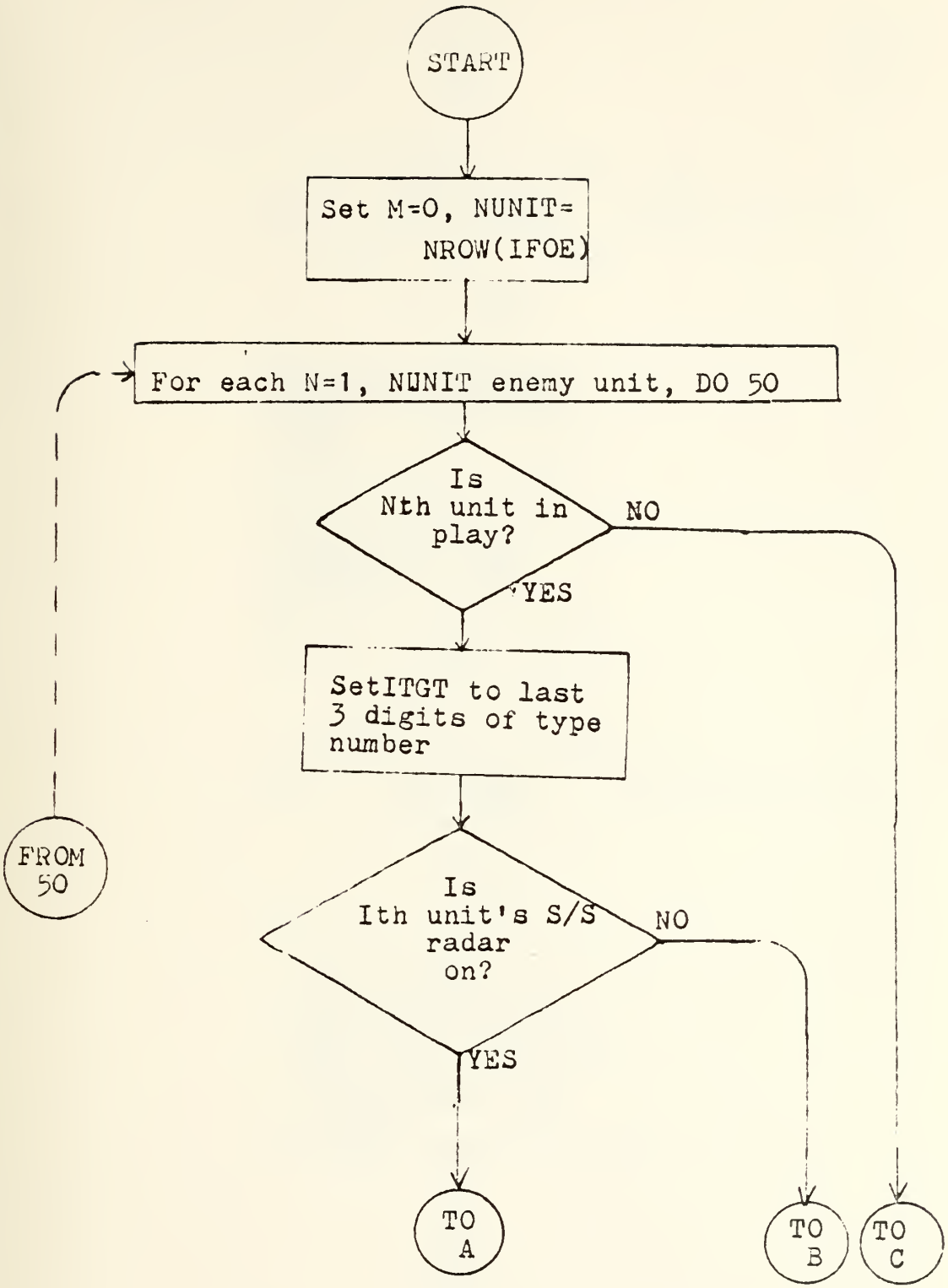
DETRAD is called from DETECT whenever a unit has either an air or surface search radar on. Subroutine NLPCPA must have been executed last for unit I. Values from PRMAX with the third subscript 1 for surface search and 2 for air search radars must be available.

Table 11 lists the local variables of DETRAD and Figure 10 is a flowchart of the routine.

Table 11

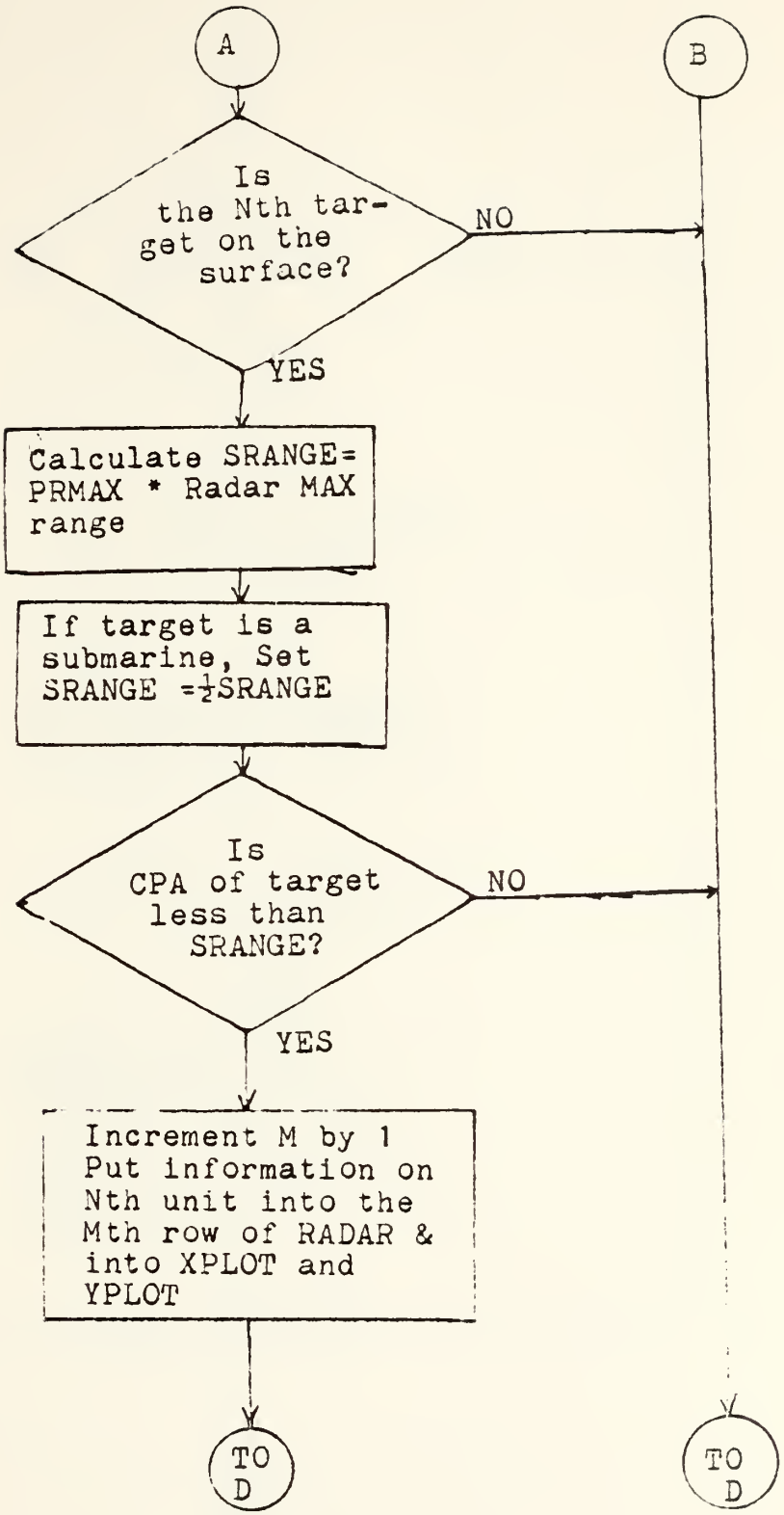
DETRAD, Local Variables

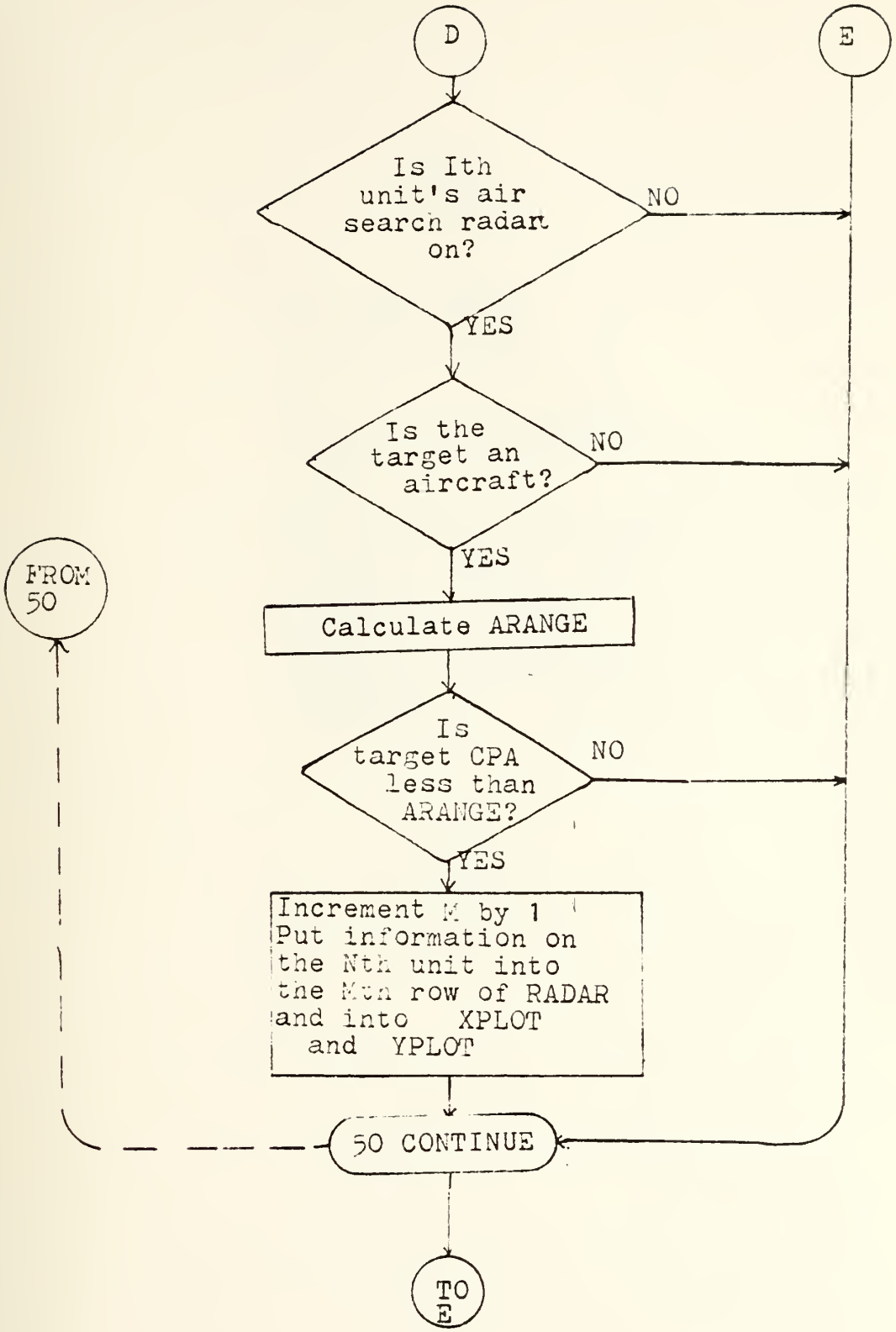
Variable	Description
ARANGE	A/S Radar calculated final detection range.
I	External argument passed from DETECT. Designates the Ith unit which is doing the detecting.
II, JJ	Row and column subscripts for printing out first 10 columns of array RADAR.
ITGT	Last three digits of the Nth unit's type number.
J	Column subscript in do loop 30 for transferring detection data to array RADAR.
M	Counter for total number of detections for unit I.
N	Subscripts the row, of the Nth enemy unit.
NUNIT	Set to total number of enemy units.
SRANGE	S/S radar calculated final detection range.

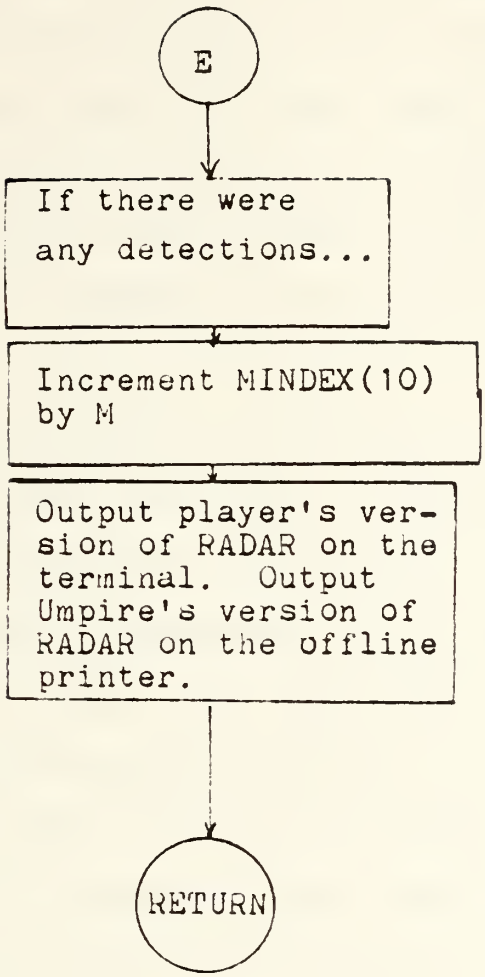


Flowchart of Subroutine DETRAD

Figure 10


A
B
Is the Nth target on the surface?
NO
YES
Calculate SRANGE= PRMAX * Radar MAX range
If target is a submarine, Set SRANGE = ½SRANGE
Is CPA of target less than SRANGE?
NO
YES
Increment M by 1
Put information on Nth unit into the Mth row of RADAR & into XPLOT and YPLOT
TO D
TO D


D
E
Is Ith unit's air search radar on?
NO
YES
Is the target an aircraft?
NO
YES
FROM 50
Calculate ARANGE
Is target CPA less than ARANGE?
NO
YES
Increment M by 1
Put information on the Nth unit into the Mth row of RADAR and into XPLOT and YPLOT
50 CONTINUE
TO E


E
If there were any detections...
Increment MINDEX(10) by M
Output player's version of RADAR on the terminal. Output Umpire's version of RADAR on the offline printer.
RETURN

8. Subroutine VISUAL

Subroutine VISUAL processes all possible visual detections of enemy units for the Ith friendly unit. Ships and surfaced submarines were arbitrarily assigned an unmodified visual detection range of 10 n.m. Aircraft were assigned a 20 n.m. range. Although an aircraft or ship can discern a target at more than the above ranges, visual detection within the framework of SEATAG implies classification opportunities as well.

Classification implies the aircraft or ship closes to read hull numbers and count masts. Rather than try to make the information provided a function of range, 10 and 20 miles were selected as reasonable values considering the aggregate level of the game. All units with the exception of submerged subs are detectable by this routine.

A detection occurs when the calculated CPA of the target is less than the assigned visual detection range. The information on the detection is stored in columns 11-20 of array RADAR.

The two arguments passed to VISUAL are I which designates the row in array DATA of the unit attempting to make the detection and ITYPE which tells the subroutine if the Ith unit is an aircraft or surface unit.

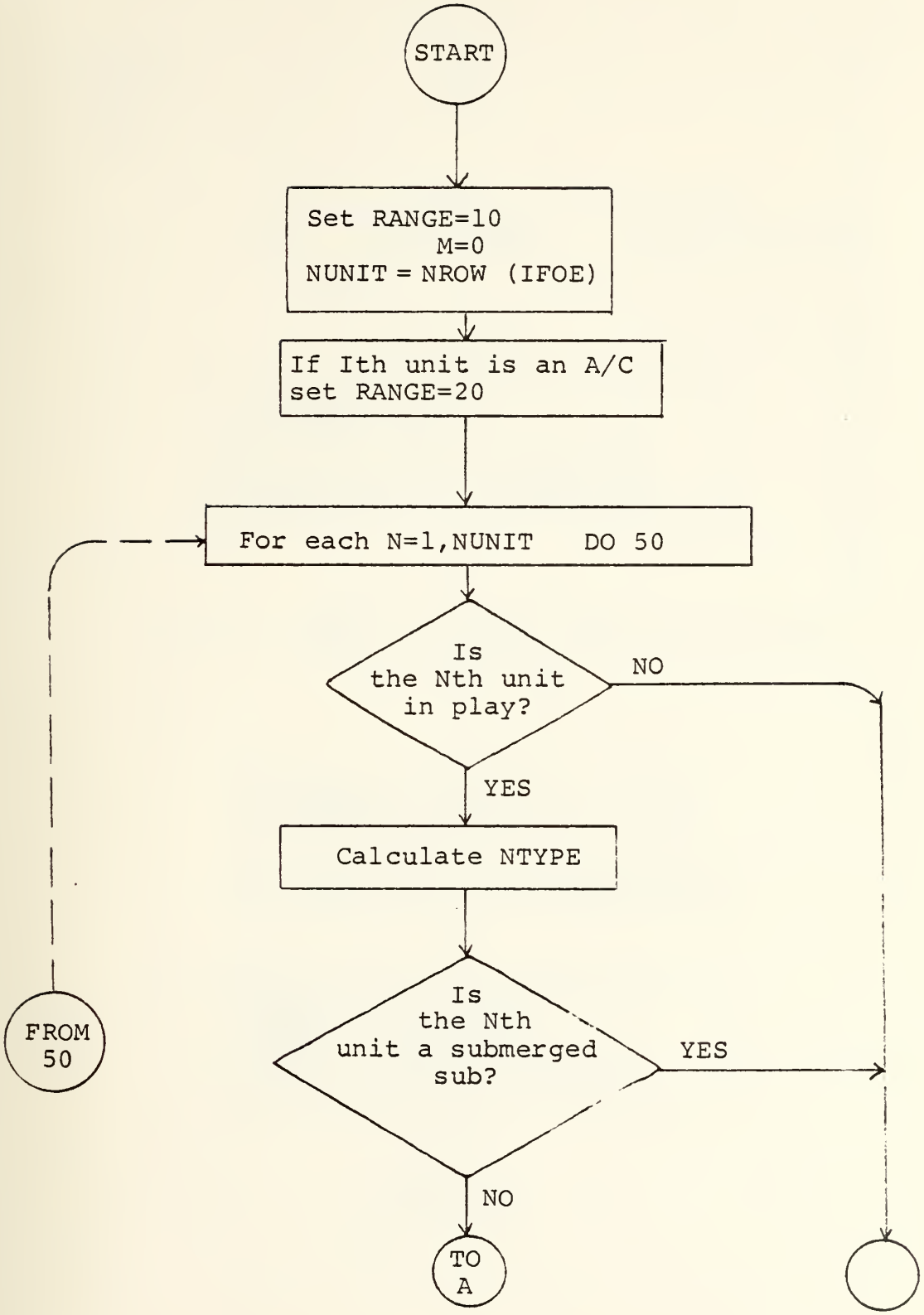
This subroutine is called from DETECT when the Ith unit is an aircraft, ship, or a surfaced submarine and game time is between 0600 and 1800 hours. Subroutine NLPCPA must have been executed last for unit I.

Table 12 lists the local variables and Figure 11 is a flowchart of subroutine VISUAL.

Table 12

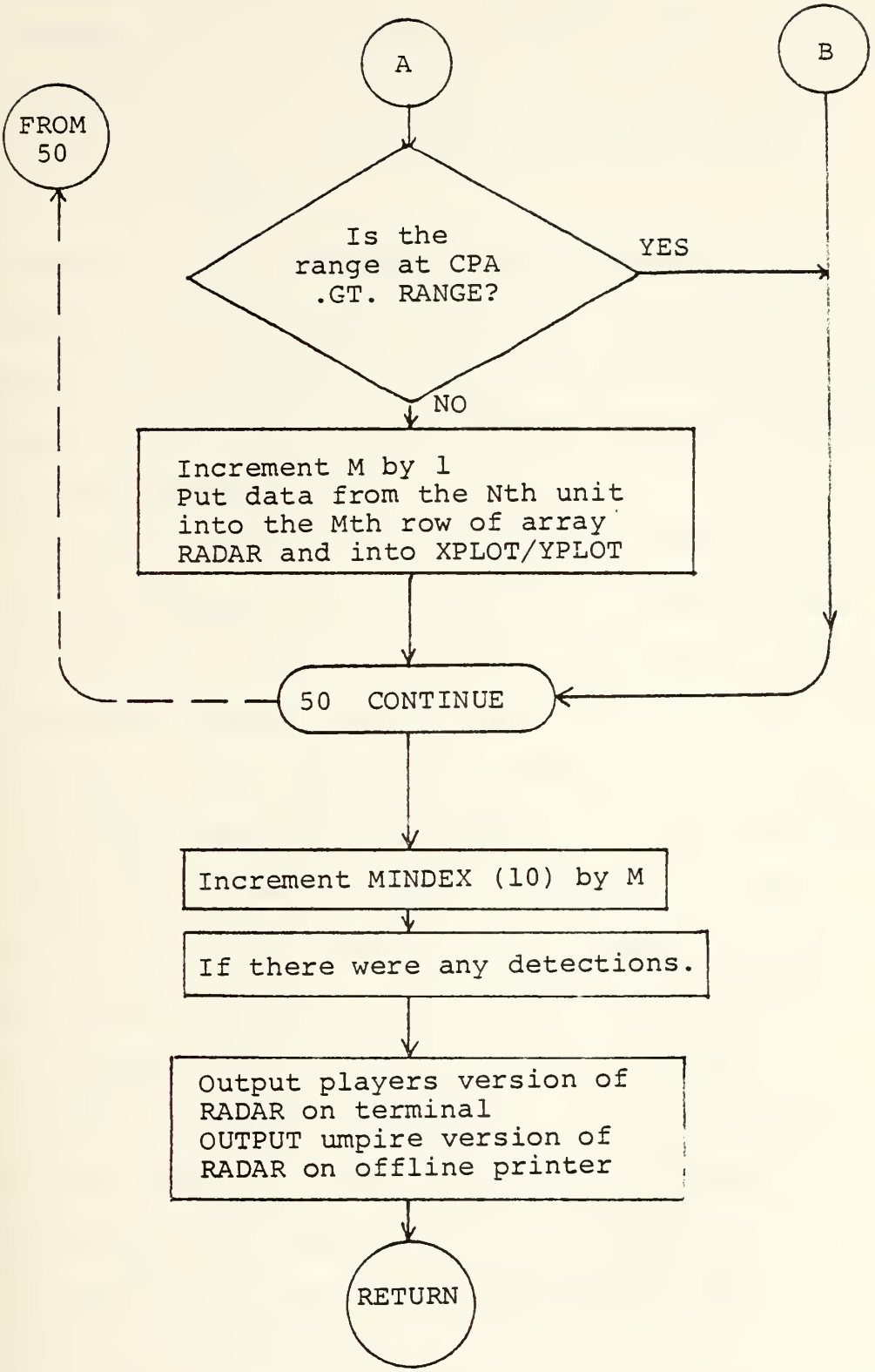
Subroutine VISUAL, Local Variables

Variable	Description
I	Argument passed from DETECT denoting the Ith unit doing the searching.
II, JJ	Row and column subscripts for printing out columns 11-20 of array RADAR.
ITYPE	Last two digits of Ith unit type number if aircraft, last three digits if unit submarine or ship.
M	Counter for number of visual detections for the Ith unit.
N	Row subscript denoting the Nth enemy unit.
NTYPE	Last three digits of Nth unit's type number.
NUNIT	Total number of enemy units.
RANGE	Set to 10 n.m. if Ith unit on surface, 20 n.m. if Ith unit an aircraft.



Flowchart of Subroutine VISUAL

Figure 11


A
B
FROM 50
Is the range at CPA .GT. RANGE?
YES
NO
Increment M by 1
Put data from the Nth unit into the Mth row of array RADAR and into XPLOT/YPLOT
50 CONTINUE
Increment MINDEX (10) by M
If there were any detections.
Output players version of RADAR on terminal
OUTPUT umpire version of RADAR on offline printer
RETURN

9. Subroutine ASONAR

ASONAR, for active sonar, determines possible active sonar detections by the Ith friendly unit. The unit's sonar must be active and the unit's speed less than 15 knots prior to calling ASONAR.

Surface ships, submarines and helicopters with dipping sonars may make active detections. Only submerged submarines, either friendly or enemy, may be detected by an active sonar. No differentiation is made between a friendly or enemy submarine detection.

Level 5 of PRMAX is used for active sonar detections of own units although it is normally used in determining passive performance. This is to avoid correlating active sonar performance against the Nth enemy unit with that against the Nth friendly unit. This avoids adding another level (K = 6) to array PRMAX for what amounts to a rare occurrence.

The only argument passed to ASONAR is I. This specifies the row of the friendly unit attempting to make the active sonar detections and is used as the row subscript to access the Ith unit's data in array DATA.

ASONAR is called from DETECT. Values for percent of maximum range from array PRMAX with the third subscript equal to four and five are required before the subroutine is called. NLPCPA must have been called last for the Ith unit prior to calling ASONAR.

Prior to the second time through do loop 60, NLPCPA is called from ASONAR. After IFOE is set to ID, NLPCPA

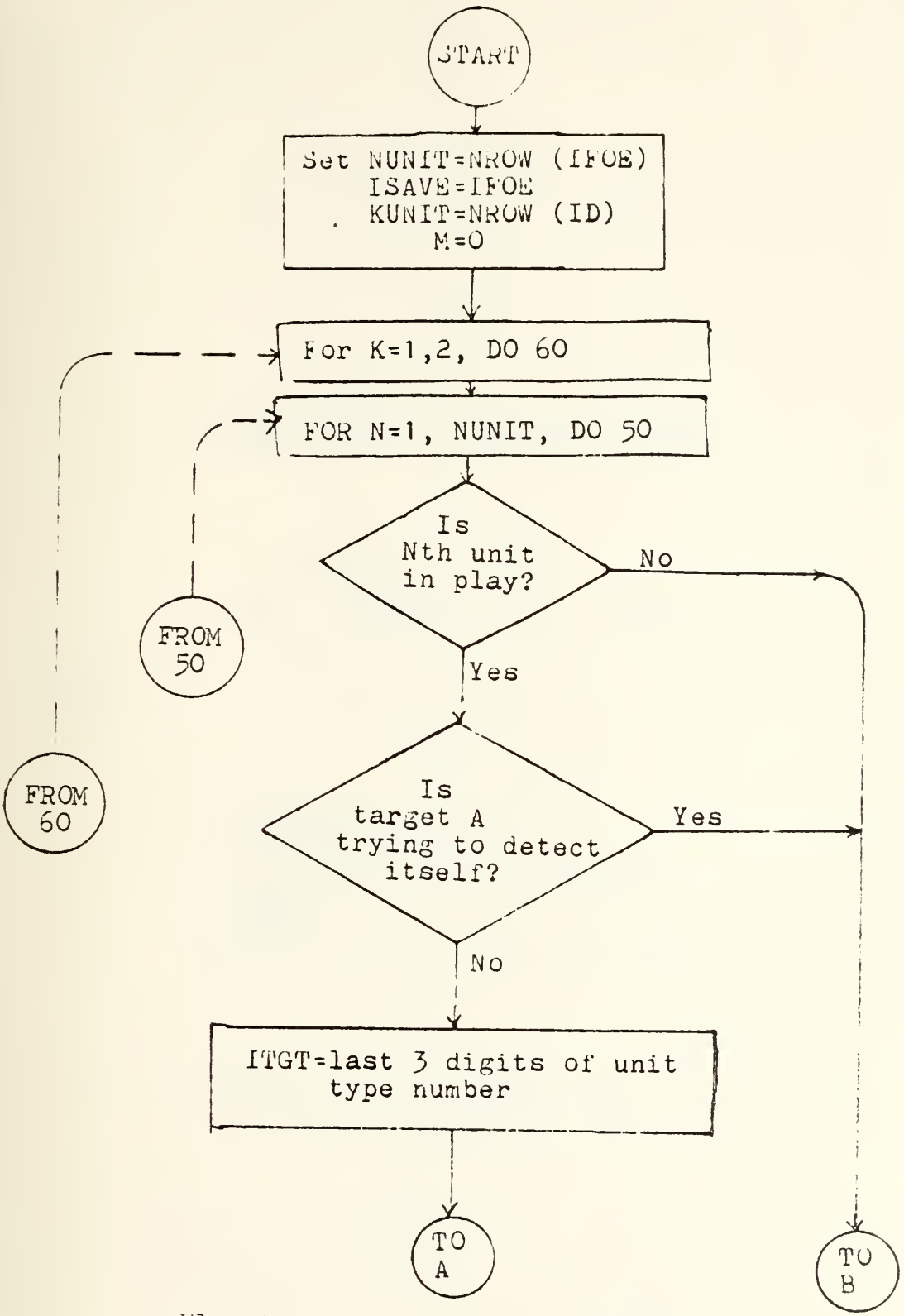
calculates the CPA of all friendly units and stores the values in array CPA. This is the only instance of a subroutine being called from a subroutine other than from DETECT in program SEARCH. Note that ASONAR must be the last subroutine called for detections by the Ith unit in DETECT due to its calling NLPCPA as the values in array CPA will be those of friendly units.

Detections for the Ith unit are stored in the first ten columns of array SONAR by row. Table 13 lists the local variables of ASONAR. Figure 12 is a flowchart of ASONAR.

Table 13

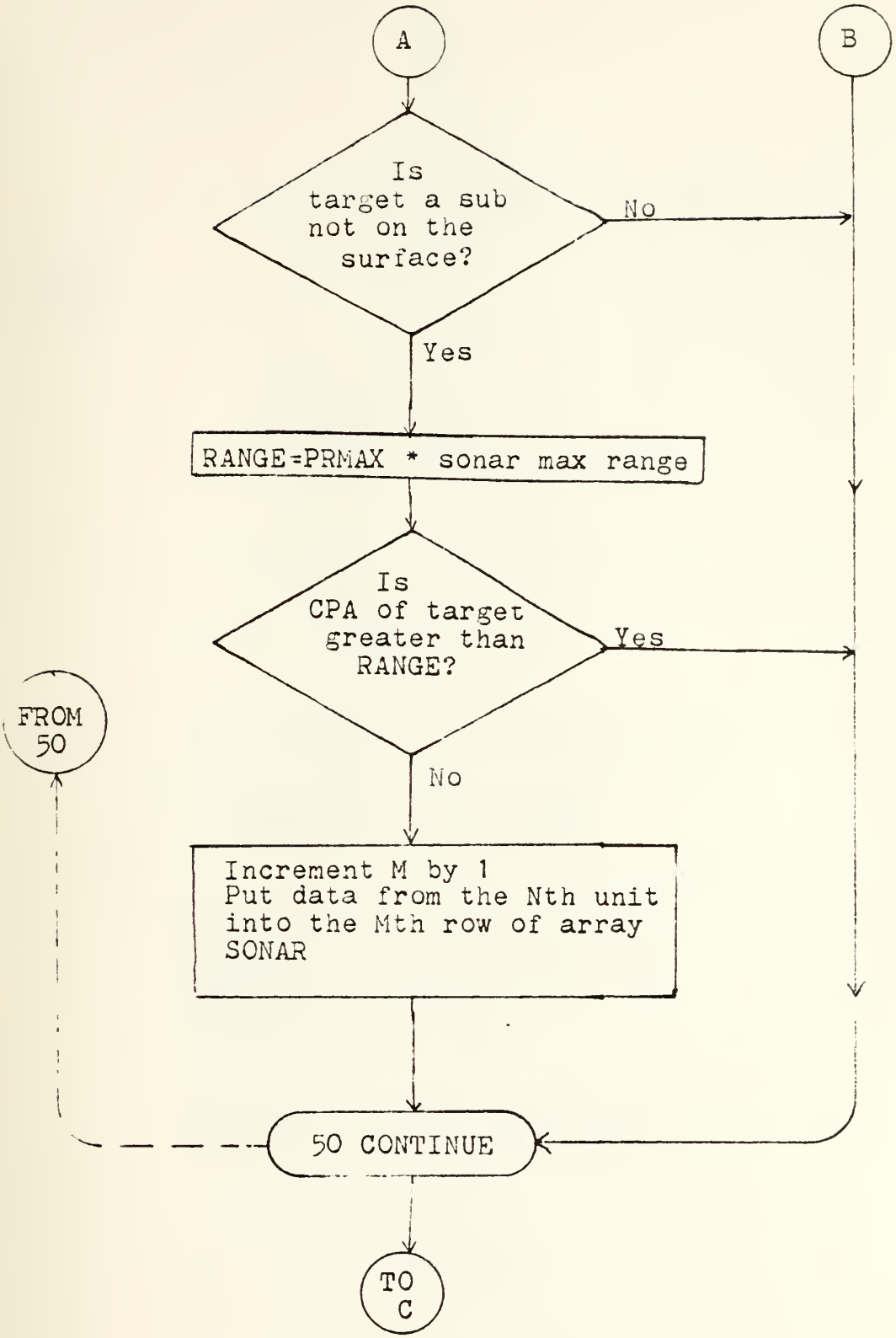
Subroutine ASONAR, Local Variables

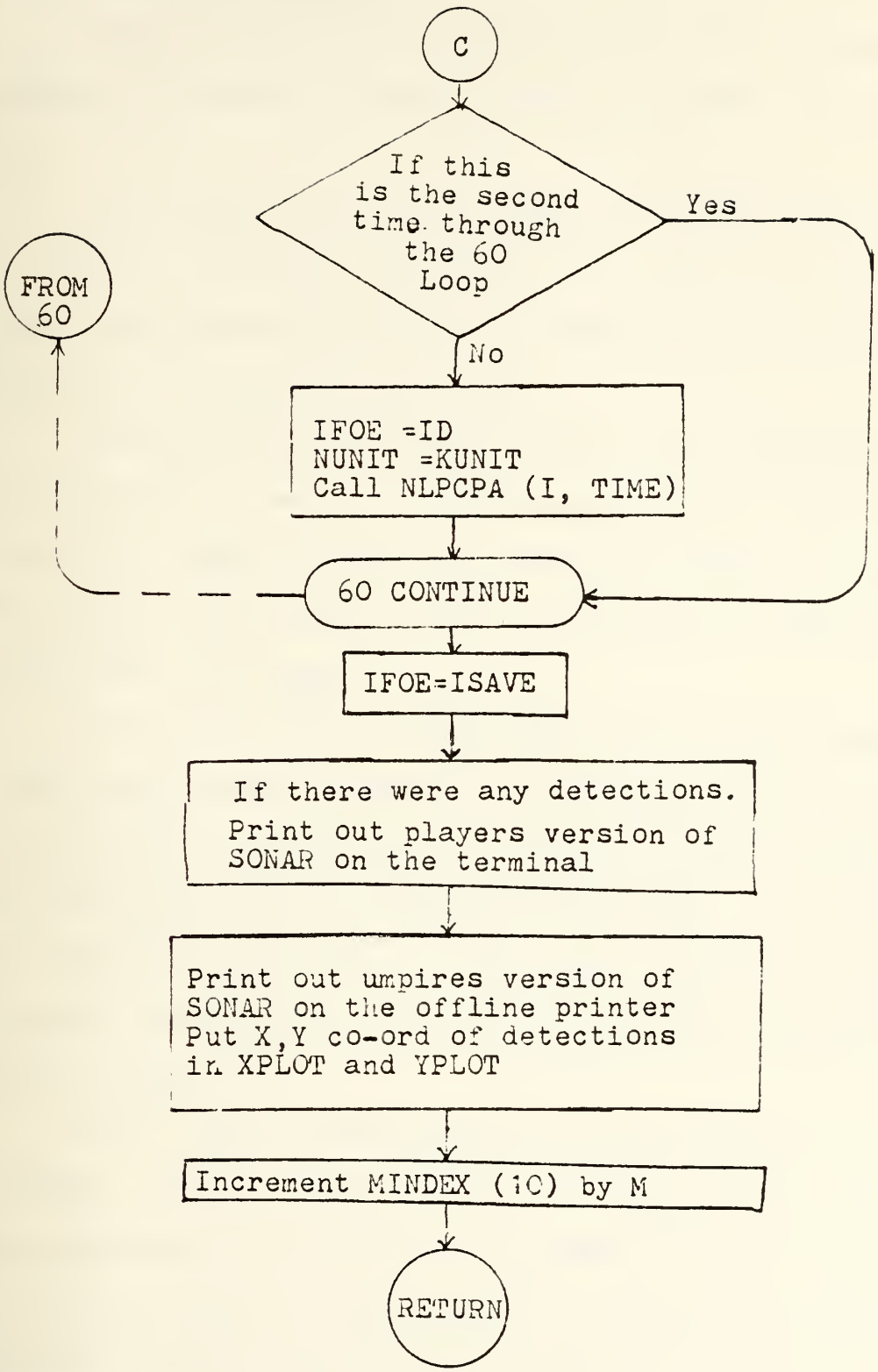
Variable	Description
I	Argument passed from DETECT denoting the Ith unit attempting active sonar detections.
IA	Column subscript in do loop 40 to transfer detection data to array SONAR.
II, JJ	Row and column subscripts for printing out array SONAR.
ISAVE	Saves value of IFOE while IFOE = ID.
ITGT	Last three digits of the Nth unit's type number.
K	Counts twice through do loop 60.
KUNIT	Set to total number of friendly units.
M	Counter for total number of active sonar for the Ith unit.
N	Row subscript denoting the Nth enemy when K = 1 or friendly when K = 2 unit.
NUNIT	Set to total number of enemy units when K = 1, total number of friendly units when K = 2.
RANGE	Active sonar calculated final maximum detection range.
TIME	Argument passed to NLPCPA denoting this turn's length in minutes.



Flowchart of Subroutine ASONAR

Figure 12


A
B
Is target a sub not on the surface?
No
Yes
RANGE=PRMAX * sonar max range
Is CPA of target greater than RANGE?
Yes
No
FROM 50
Increment M by 1
Put data from the Nth unit into the Mth row of array SONAR
50 CONTINUE
TO C


C
If this is the second time through the 60 Loop
Yes
No
FROM 60
IFOE =ID
NUNIT =KUNIT
Call NLPCPA (I, TIME)
60 CONTINUE
IFOE=ISAVE
If there were any detections.
Print out players version of SONAR on the terminal
Print out umpires version of SONAR on the offline printer
Put X,Y co-ord of detections in XPLOT and YPLOT
Increment MINDEX (IC) by M
RETURN

10. Subroutine NLPCPA

NLPCPA calculates the range in n.m. and the bearing in degrees of the CPA of every enemy unit to the Ith friendly unit.

The final CPA is in fact the CPA during the last turn. In most instances this turns out to be the initial or final position of the Nth unit, depending on if that unit is opening or closing the Ith unit.

The subroutine uses each unit's (X,Y) coordinates, course and speed as well as the elapsed time and clock time of this turn. Recall that since subroutine MOVE is called before NLPCPA, the values of the coordinates are where the units are after the move.

The method used in this subroutine to determine the CPA takes the approach commonly used underway where the relative position of the target is known and the target's course, speed and CPA are determined from that. This will appear somewhat round about as the target course and speed are already available and a normal trigonometric approach would be feasible.

Point (A,B) is the position of the Ith unit at time ZTIME. (X2,Y2) is the relative as well as the geographic position of the Nth unit at ZTIME. Both of these points are available in array DATA. A previous relative position of the Nth unit to the Ith unit must be calculated. This point (X1,Y1), will be calculated as the relative position of the target at time (ZTIME-TIME), or the game time

at the beginning of this turn. (X1,Y1) is not the position of the target at the beginning of this turn. It is a relative position at which the target may never have been. A geometric diagram of the calculation of (X1,Y1) is provided as Figure 13.

To calculate (X1,Y1) the X and Y distance traveled by the target is subtracted from point (X2,Y2) giving the position of the target at the start of this turn. Then the X and Y distance traveled by the Ith unit is added, resulting in X1 and Y1:

$$X1 = X2 - D1 * (SIN(THETA)) + XDIST \qquad (1)$$

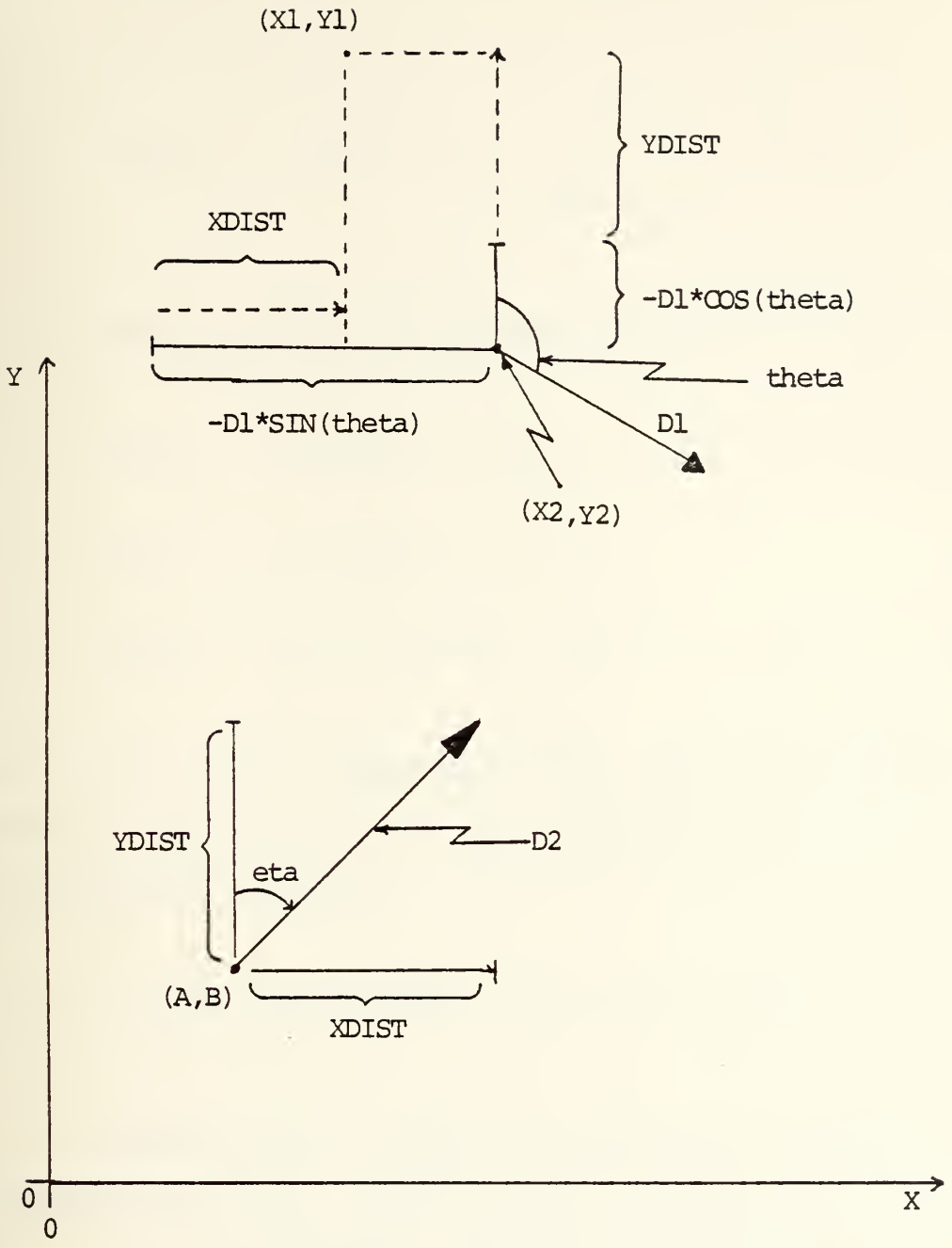
$$Y1 = Y2 - D1 * (SIN(THETA)) + YDIST \qquad (2)$$

To determine the CPA, the problem is to find the shortest distance from point (A,B) to the line defined by the two relative points (X1,Y1) and (X2,Y2). This line is called the DRM for Direction of Relative Movement. The slope is called DX. Formulating the problem as a non-linear programming problem gives

$$MIN\ f(x,y) = SQRT((X - A)^2 + (Y - B)^2) \qquad (3)$$

$$\text{subject to} \quad Y - Y1 = DX * (X - X1) \qquad (4)$$

Using the LaGrange multiplier technique, we minimize the square function minus lambda times the constraint



$$X1 = X2 - XDIST - D1*SIN(THETA)$$

$$Y1 = Y2 - YDIST - D1*COS(THETA)$$

CALCULATION OF (X1,Y1)

Figure 13

(Eq. 5) which will have the same minimum as Equation 3.

$$F(x,y) = (X - A)^2 + (Y - B)^2 - L * (Y - Y1 - DX(X - X1)) \quad (5)$$

Taking partial derivatives yields

$$\partial F/\partial X = 2X - 2A + L * DX = 0 \quad (6)$$

$$\partial F/\partial Y = 2Y - 2B - L = 0 \quad (7)$$

$$\partial F/\partial L = DX * (X - X1) + Y1 - Y = 0 \quad (8)$$

Equation (7) gives an expression for L and (8) gives an expression for Y in terms of X. Substituting these in (6) and solving for X yields

$$X = (A + B \times DX + X1 \times DX^2 - Y1 * DX)/(1 + DX^2) \quad (9)$$

Equation (9) is how X is calculated in NLPCPA. Y is computed from (8). (X,Y) is the coordinate of the CPA.

In the calculation of DX, if the absolute value of (X2 - X1) is within .001 of zero, the CPA calculation is not needed since DX is infinite or nearly so. Practically speaking in this case, X2 = X1 and the DRM is vertical, yielding a CPA of (X2,B).

If both (X2 - X1) and (Y2 - Y1) are less than EPS, then X2 = X1 and Y2 = Y1 implying the two units involved are on the same course and speed. The CPA is set to (X2,Y2) in this case.

In Figure 13, the CPA falls conveniently between (X1,Y1) and (X2,Y2). In fact we have three cases to consider in deciding on the final CPA. Figure 14 shows the three possibilities. The relative positions of (X1,Y1) and (X2,Y2) may or may not be reversed, giving six possibilities to check.

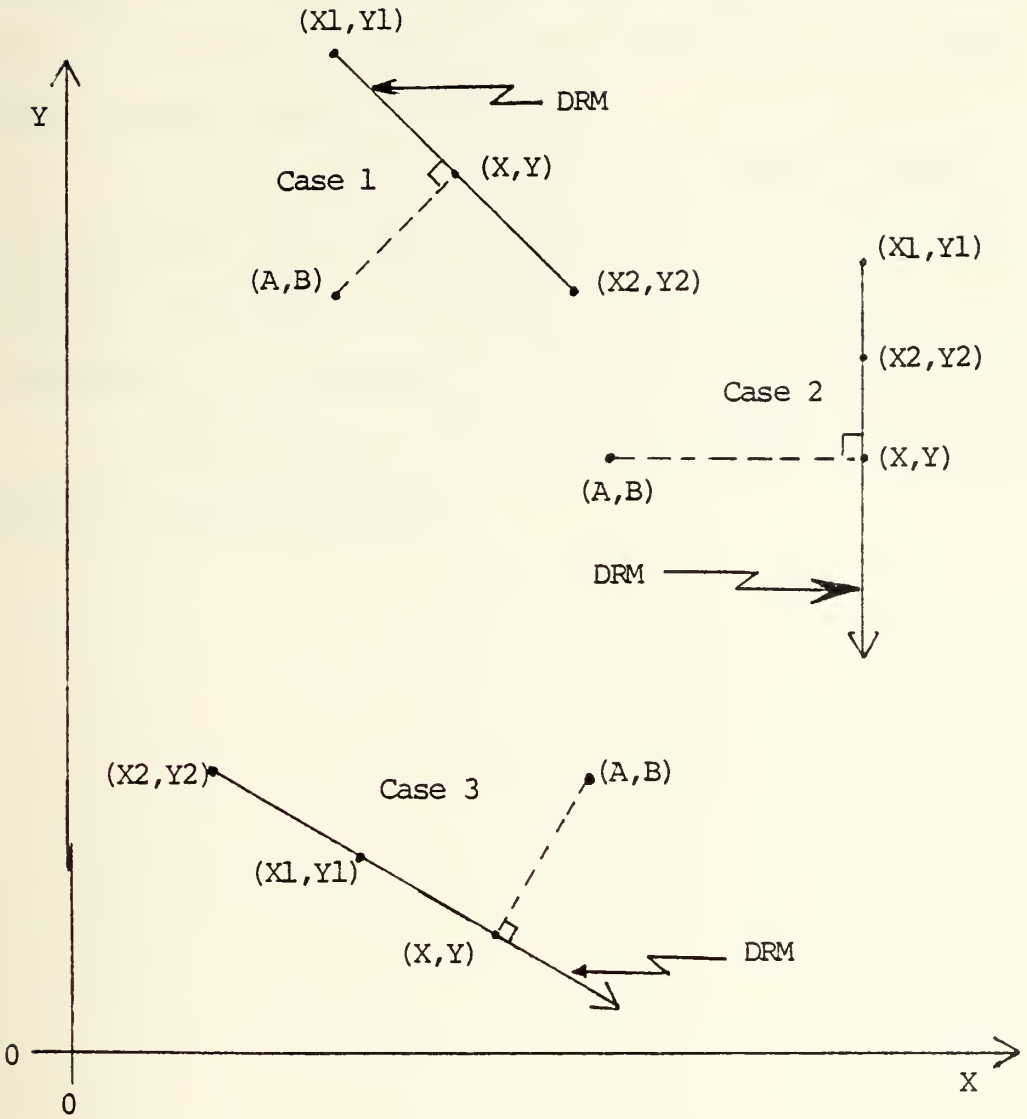
Two series of four logical FORTRAN IF statements branch to assign the appropriate final value for (X,Y).

Once the final (X,Y) is determined, the distance from (X,Y) to (A,B) is calculated using the standard cartesian distance formula. Distances less than EPS are set to EPS to avoid dividing by zero when calculating the bearing of the CPA. The CPA range for the Nth unit is stored in CPA(N,1).

Finally the bearing of the point (X,Y) from (A,B) must be calculated and converted to degrees. TAU is the angle between line segment ((A,B),(X,Y)) and ((X,B),(X,Y)) and is calculated using the ARSIN function as

$$TAU = ARCSIN((X - A)/CPA(N,1)) \qquad (10)$$

In the first quadrant TAU will be the correct bearing. If (X,Y) is in one of the other three quadrants



Case	CPA Point
1	(X,Y)
2	(X2,Y2)
3	(X1,Y1)

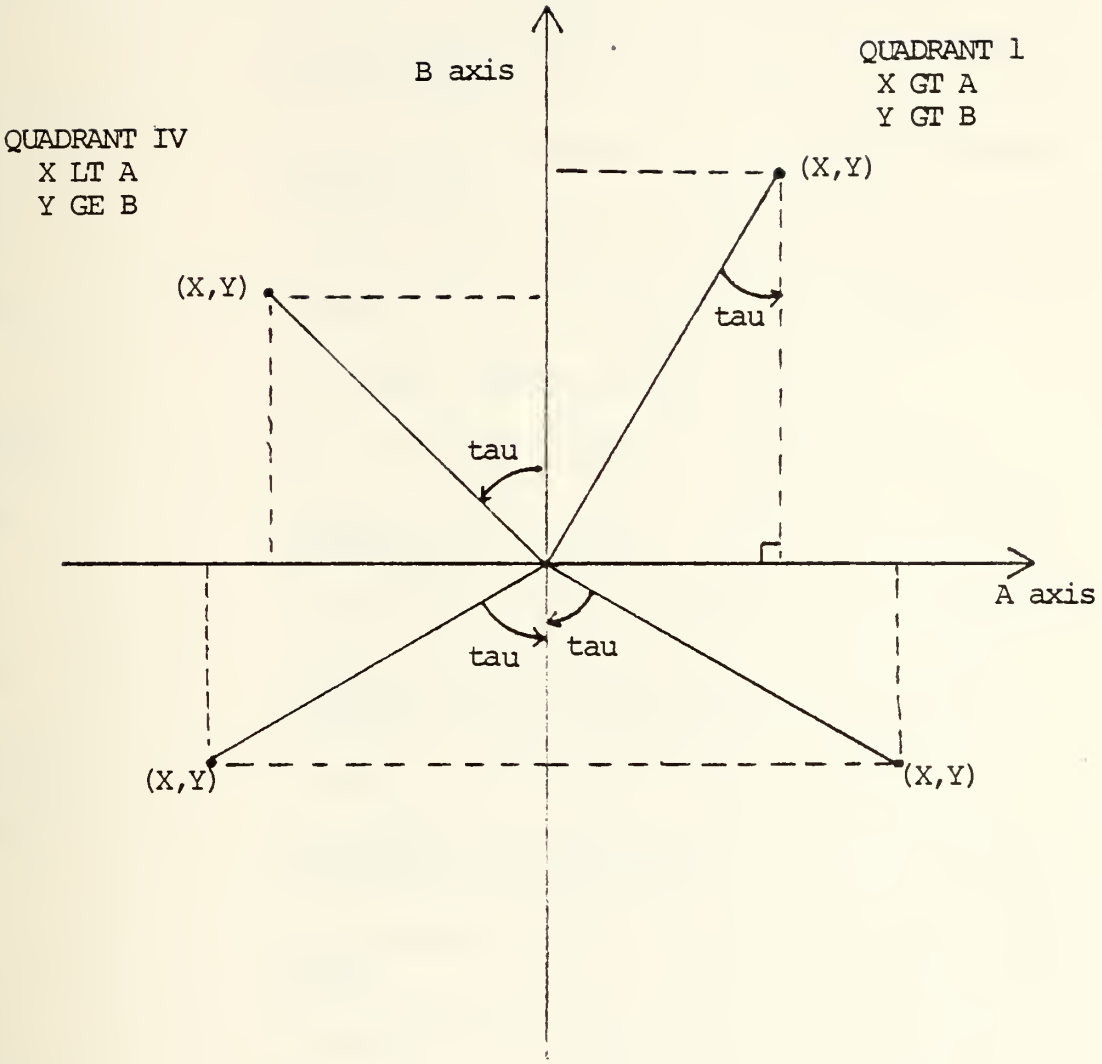
Relative Locations of DRM Endpoints

Figure 14

of (A,B) TAU must be modified as shown in Figure 15. Finally TAU is converted to degrees and stored in CPA(N,2). The argument I passed to NLPCPA specifies the row of the friendly unit. The CPA's are calculated relative to this unit. TIME is the elapsed time for this turn.

This subroutine is called from DETECT once for each Ith (friendly) unit that is able to make any ESM, radar or sonar detections. In addition, NLPCPA may be called from ASONAR in circumstances defined in that subroutine.

Figure 16 is a flowchart for NLPCPA and Table 14 lists the local variables.



Four Quadrant Tau Calculation

Figure 15

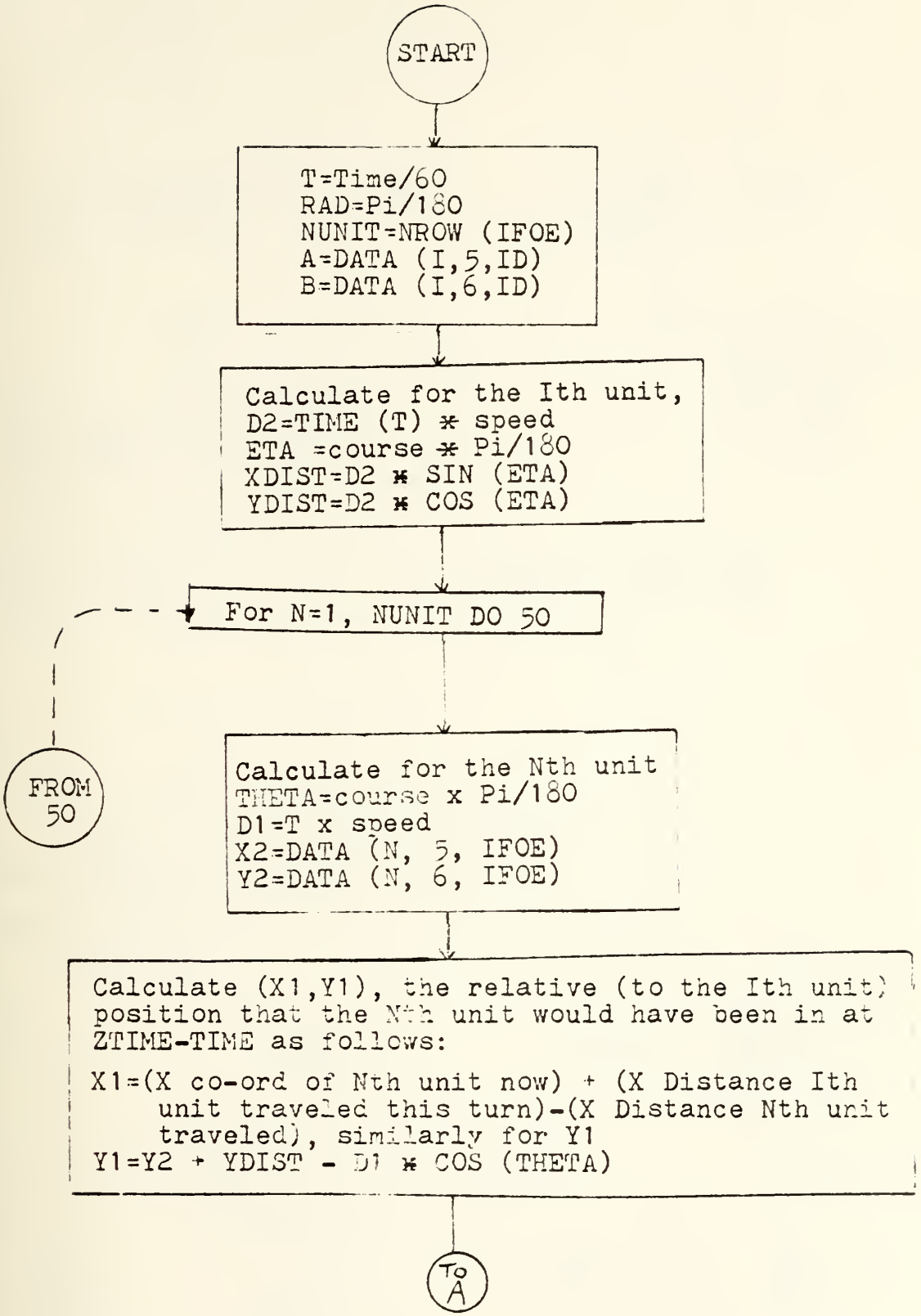
Table 14

Subroutine NLPCPA, Local Variables

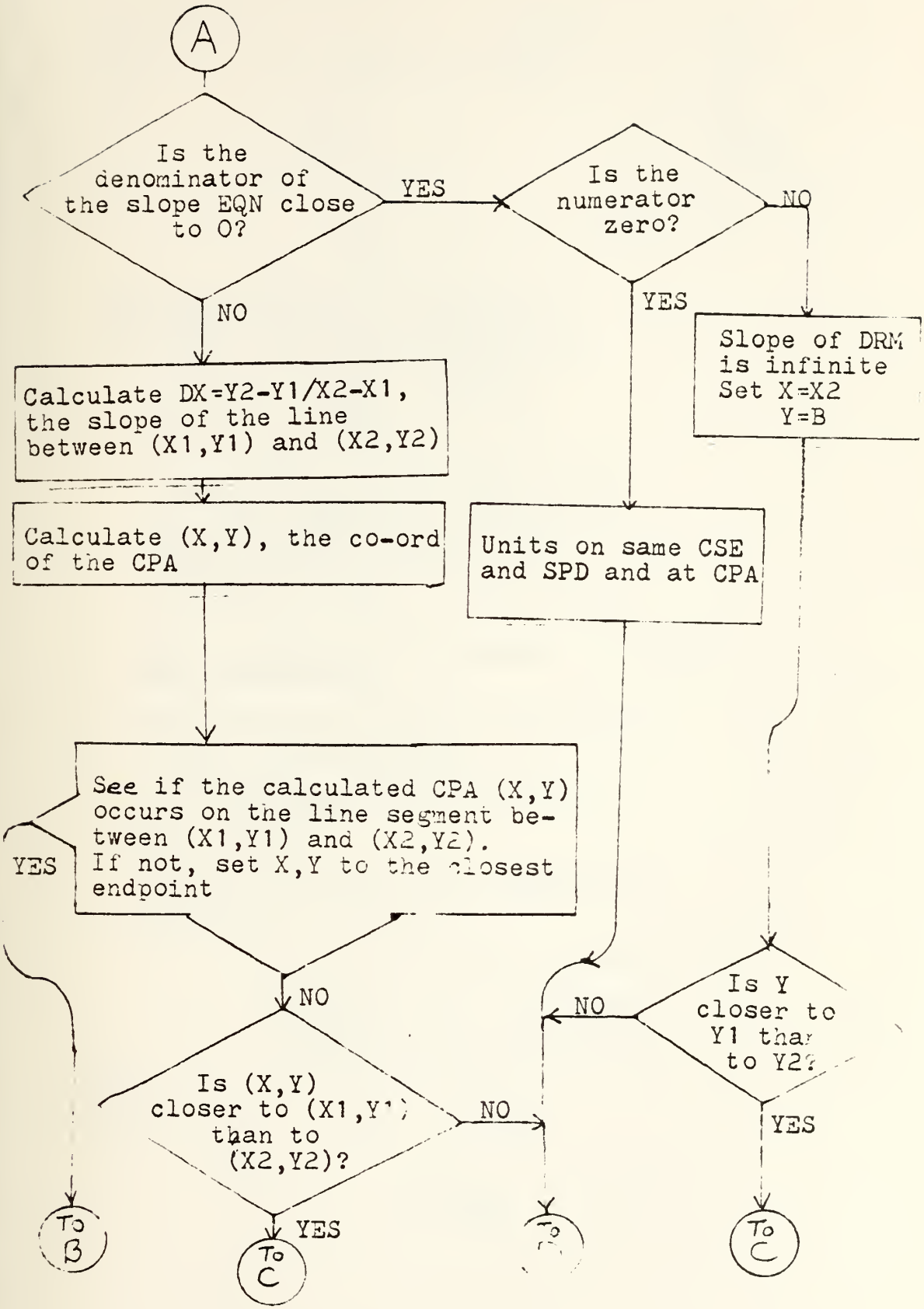
Variable	Description
A	Current X coordinate of the Ith unit.
B	Current Y coordinate of the Ith unit.
D1	Calculated distance the Nth unit moved this turn.
D2	Calculated distance the Ith unit moved this turn.
DX	Calculated slope of the DRM line.
ETA	Course of the Ith unit in radians.
I	Argument denoting the Ith unit.
NUNIT	Set to total number of enemy units.
RAD	Set to $\pi/180$. Used as degree to radian conversion factor.
T	Calculated time of this turn in hours.
TAU	Angle of the line from (A,B) to (X,Y) with the line from (X,Y) to (X,B).
THETA	Course of the Nth unit in radians.
TIME	Argument containing the elapsed time of this turn in minutes.
X	X coordinate of the calculated and final CPA.
X2	Current X coordinate of the Nth unit.
XDIST	Distance along the X-axis the Ith unit moved this turn.
Y	Y coordinate of the calculated and final CPA.
Y1	Y coordinate of the relative position of the Nth unit to the Ith at the beginning of this turn.

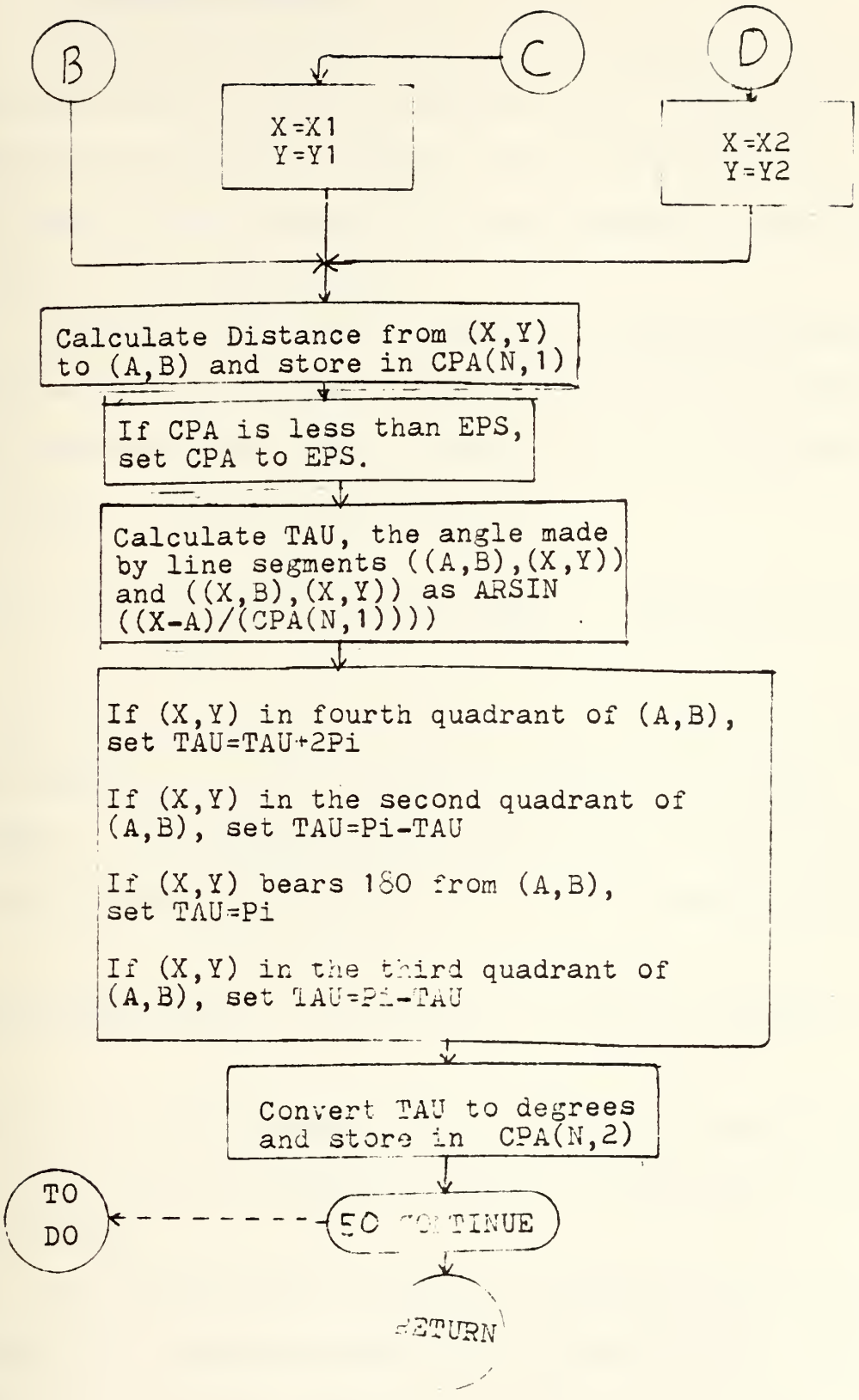
Table 14 (Continued)

Variable	Description
Y2	Current Y coordinate of the Nth unit.
YDIST	Distance along the Y-axis the Ith unit moved this turn.


START
T=Time/60
RAD=Pi/180
NUNIT=NROW (IFOE)
A=DATA (I,5,ID)
B=DATA (I,6,ID)
Calculate for the Ith unit,
D2=TIME (T) * speed
ETA =course * Pi/180
XDIST=D2 * SIN (ETA)
YDIST=D2 * COS (ETA)
For N=1, NUNIT DO 50
FROM 50
Calculate for the Nth unit
THETA=course x Pi/180
D1=T x speed
X2=DATA (N, 5, IFOE)
Y2=DATA (N, 6, IFOE)
Calculate (X1,Y1), the relative (to the Ith unit) position that the Nth unit would have been in at ZTIME-TIME as follows:
X1=(X co-ord of Nth unit now) + (X Distance Ith unit traveled this turn)-(X Distance Nth unit traveled), similarly for Y1
Y1=Y2 + YDIST - D1 * COS (THETA)
TO A

Flowchart of Subroutine NLPCPA
Figure 16


A
Is the denominator of the slope EQN close to 0?
YES
Is the numerator zero?
NO
YES
NO
Slope of DRM is infinite
Set X=X2
Y=B
Calculate DX=Y2-Y1/X2-X1, the slope of the line between (X1,Y1) and (X2,Y2)
Calculate (X,Y), the co-ord of the CPA
Units on same CSE and SPD and at CPA
See if the calculated CPA (X,Y) occurs on the line segment between (X1,Y1) and (X2,Y2). If not, set X,Y to the closest endpoint
YES
NO
Is (X,Y) closer to (X1,Y1) than to (X2,Y2)?
NO
YES
NO
Is Y closer to Y1 than to Y2?
YES
To B
To C
To
To C


B
C
D
X=X1
Y=Y1
X=X2
Y=Y2
Calculate Distance from (X,Y) to (A,B) and store in CPA(N,1)
If CPA is less than EPS, set CPA to EPS.
Calculate TAU, the angle made by line segments ((A,B),(X,Y)) and ((X,B),(X,Y)) as ARSIN ((X-A)/(CPA(N,1))))
If (X,Y) in fourth quadrant of (A,B), set TAU=TAU+2Pi
If (X,Y) in the second quadrant of (A,B), set TAU=Pi-TAU
If (X,Y) bears 180 from (A,B), set TAU=Pi
If (X,Y) in the third quadrant of (A,B), set TAU=Pi-TAU
Convert TAU to degrees and store in CPA(N,2)
TO DO
50 CONTINUE
RETURN

11. Subroutine PSONAR

Subroutine PSONAR determines all possible passive sonar detections by the Ith friendly unit. Ships and submarines at any depth attempt passive detections if their sonar is off (passive) and their speed is less than 17 and 22 knots respectively.

There are two kinds of passive detections possible in this subroutine. First, an active sonar may be detected with a passive sonar. This is analogous to an ESM detection of a radar. Range is calculated as:

Range = 2 * (Percent effectiveness) * (Range of active sonar)

If this is less than the calculated CPA, a detection occurs. Sonar ESM detections are stored in the last 10 columns of SONAR. n approximate range is provided to the detecting unit for an ESM passive detection. This is calculated as:

Approximate Range = CPA Range + CPA Range * (DICE (N) - .5)

DICE (N) is a U(0,1) random number. The approximate range will be uniformly distributed between one-half and 1.5 the range at CPA.

The second type of passive detection is the passive tracking of a target by sonar. The target's range, bearing, course, and speed are determined by the tracking unit. Any target, with the exception of aircraft, may be detected.

To calculate if a passive detection has occurred, the unit's maximum detection range is calculated as a function of target speed, searcher speed and where the target and searcher are with respect to the layer.

The curves in the top half of Figure 17 are used when a shallow sub is attempting to detect a u nit on the surface or two submerged subs are attempting to detect one another at the same depth. This is called Case 1. The curves were approximated by a family of ellipses whose parameters are functions of target speed. The solid curves are those given in the SEATAG manual and the dashed curves those of the ellipse approximations.

The ellipse parameters for Case 1 are calculated as follows:

A = (Target Speed/5) + 15

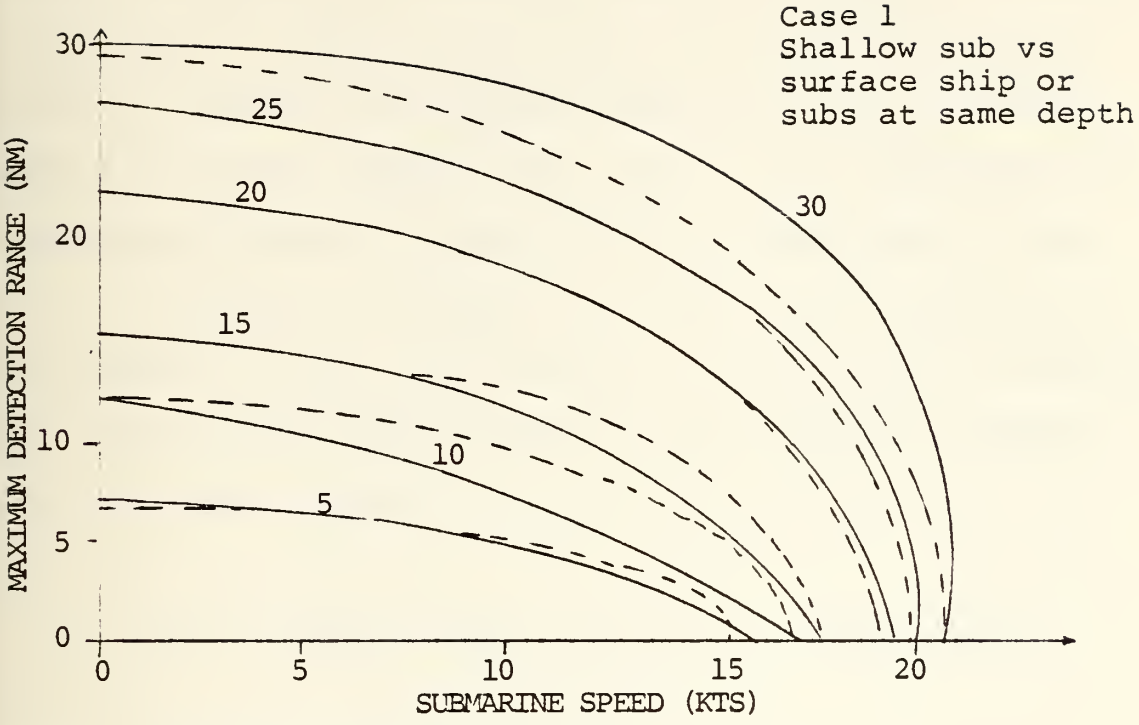
B = Target Speed + 2

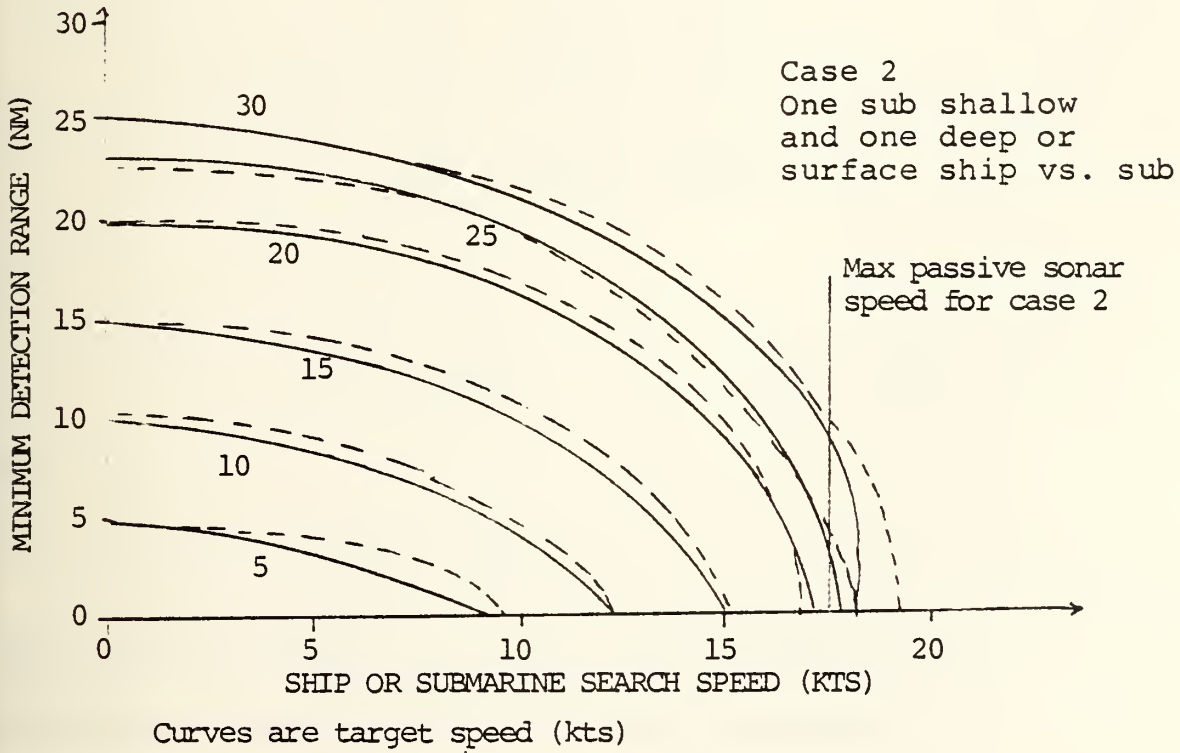
X = Searching unit speed

For the ellipse

$$\frac{X^2}{A^2} + \frac{Y^2}{B^2} = 1$$

Solving for $Y = B * (1 - (X^2/A^2)$ gives the maximum passive sonar detection range in n.m. calculated by the sub-routine. The maximum range error is plus or minus 3 n.m. from the original curves.





Comparison of Passive Sonar Detection Curves

Figure 17

The curves in the bottom half of Figure 17 represent a cross layer detection situation. This is referred to as Case 2. They are used for any unit on the surface trying to detect any submerged submarine, for deep subs trying to detect surface units, and for two submerged submarines at different depths trying to detect each other.

A series of ellipses was also used to approximate the original curves. The values of X and Y remain unchanged. The A and B parameters for Case 2 are calculated differently as shown below:

$$A = \text{Target speed} + C * (15 - \text{Target speed})$$

where

$C = .4$ if target speed < 16

$C = .6$ if target speed > 15 and ≤ 24

$C = .7$ if target speed > 25

and

$B = \text{Target speed}$ if target speed < 21

or

$B = (\text{Target speed}/2) + 10$ if target speed ≥ 21

The following table gives the A and B parameters as a function of target speed for 5 knot increments:

Case 2

TGT SPD	A	B
0	6	0
5	9	5
10	12	10
15	15	15
20	17	20
25	18	22.5
30	19.5	25

In Case (2) the vertical marks where the curves are truncated at a maximum of an 18 knot searcher speed. This in effect means much of the poorer fitting 30 knot curve is not used. The worst distortion is for a 17 knot search speed against a 25 knot target which results in a 7 n.m. range vice the 5 n.m. range obtained using the curves manually.

In some cases it is possible the searcher's speed will be greater than the calculated A values. In this case no detection should be possible so A is set equal to zero, insuring Y will be zero. If the calculated Y value is greater than the listed sonar max range on the characteristic card, Y is set to the maximum range from the characteristic card. This happens most frequently with surface ship short range sonars.

Once Y is determined, it is multiplied by the percent of maximum range (the PRMAX value) to give the final range. This is then compared with the CPA to determine if

a detection did in fact take place. Detections are then stored sequentially by row in the first ten columns of array SONAR.

The argument I passed to PSONAR specifies the row of the friendly unit attempting to make the passive detections and is used in PSONAR to access information for the Ith unit for array DATA. The argument IPLAT designates the searching unit as a surface ship or submarine.

Subroutine ASONAR is called from subroutine DETECT. Subroutine NLPCPA must have been previously called last for unit I. Values from array PRMAX with the third subscript K = 5 are used for the percent of maximum range.

Table 15 provides a list of local variables and Figure 18 a flowchart for subroutine PSONAR.

Table 15

Subroutine PSONAR, Local Variables

Variable	Description
A	Parameter of ellipse in standard form.
B	Parameter of ellipse in standard form.
B2	Used to calculate B as a function of target speed.
C	Used to calculate A as a function of target speed.
I	Argument passed from DETECT denoting the Ith unit searching passively.
IA	Column subscript in do loop 33 used to transfer data on the Mth detection into array SONAR.
II, JJ	Row and column subscripts for printing out columns of array SONAR.
IK	Column subscript used in do loop 55 to transfer the MMth passive detection data into array SONAR.
IPLAT	Argument passed from DETECT denoting the type of searching platform, 1 for a submarine, 2 for a surface unit.
M	Counter for the number of passive sonar ESM detections.
M1	Lower bound on the row subscript of array SONAR when printing out passive detections.
MM	Counter for the number of passive sonar detections. Starts from M.
N	Row subscript denoting the Nth enemy unit used in do loop 35 and 60.
NTGT	Last three digits of the Nth unit's type number.
NUNIT	Set to total number of enemy units.
RANGE	Calculated final detection range in n.m.

Table 15 (Continued)

Variable	Description
X	Searchers speed (Ith units speed in knots).
Y	Calculated detection range before modification by PRMAX.

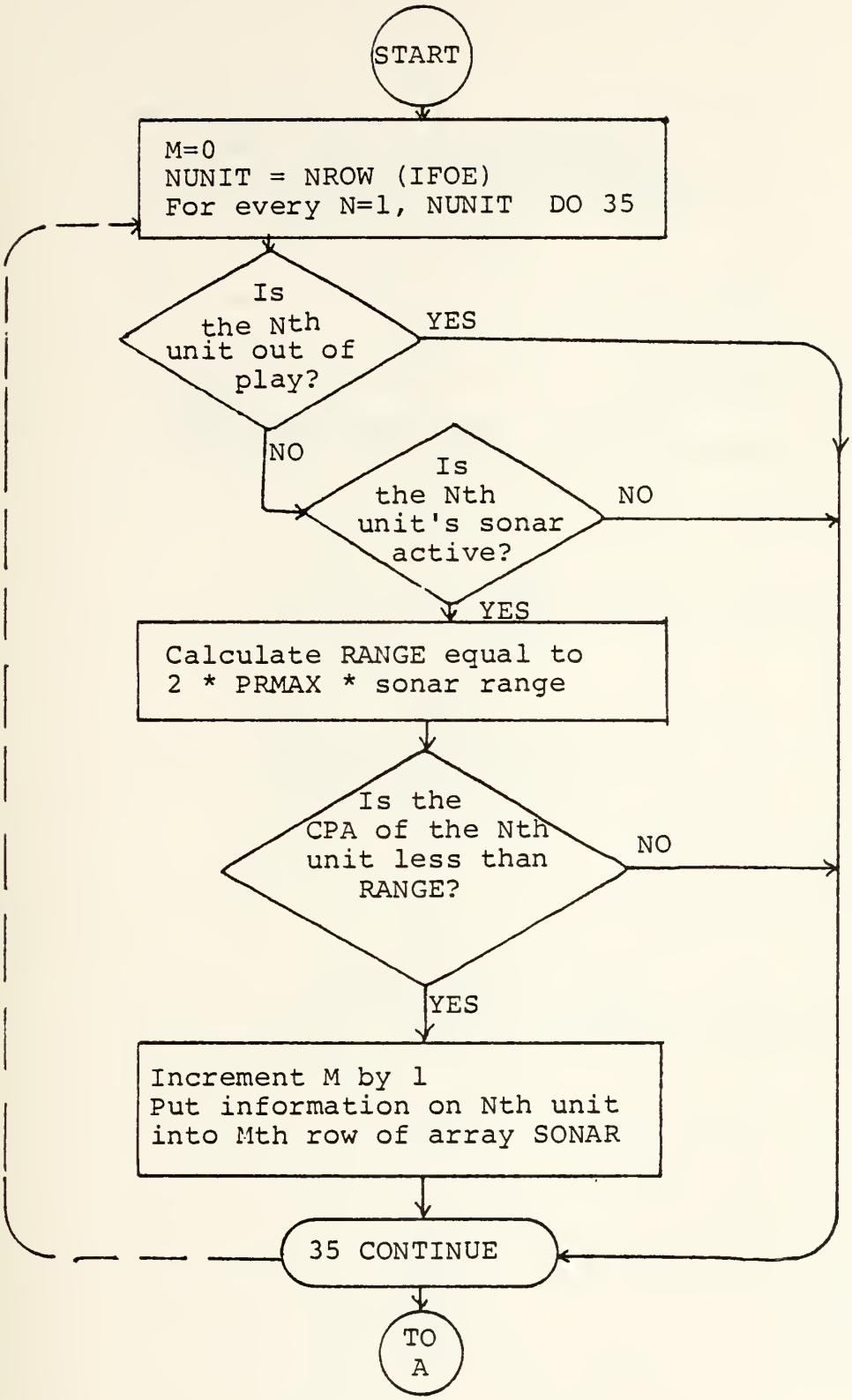
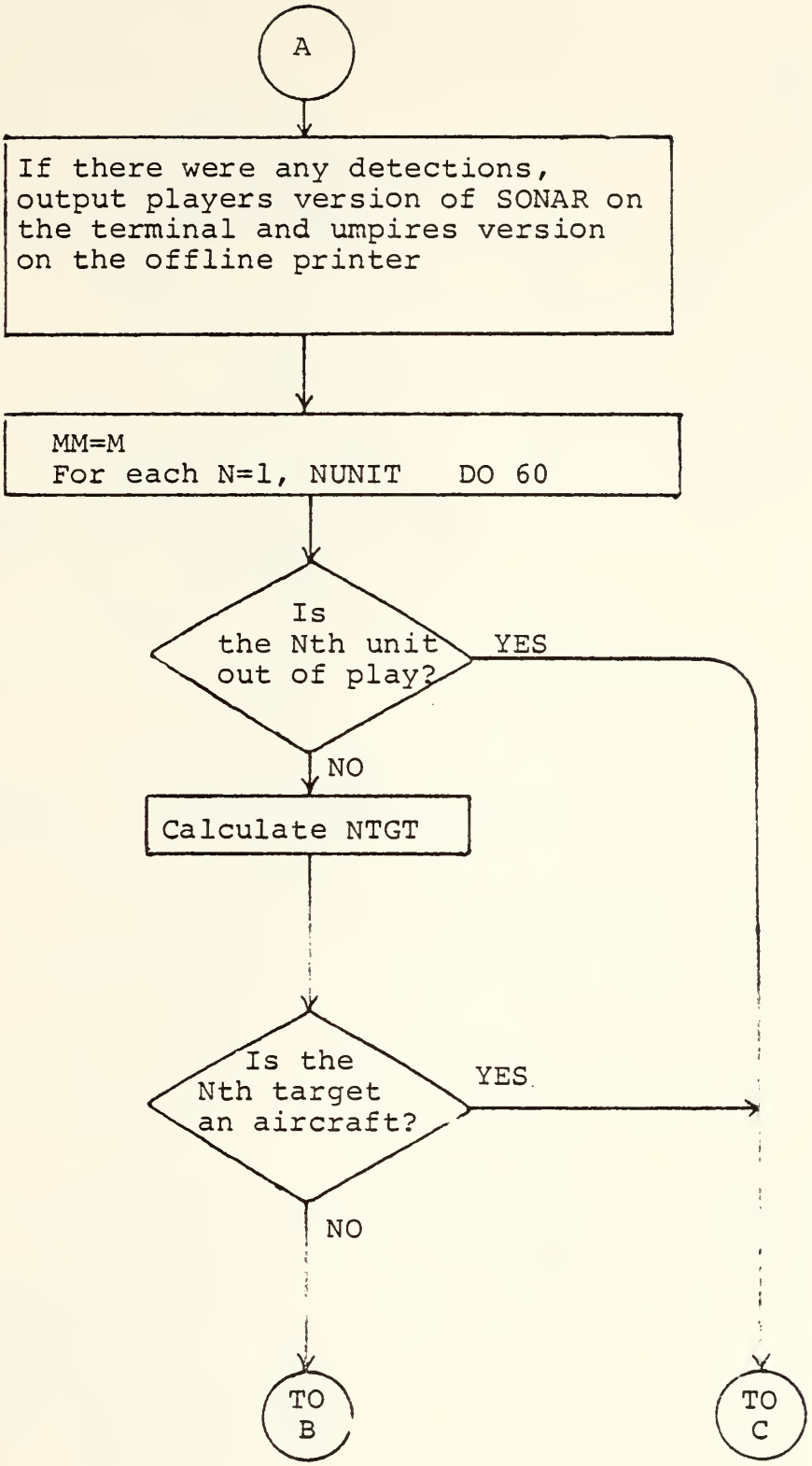
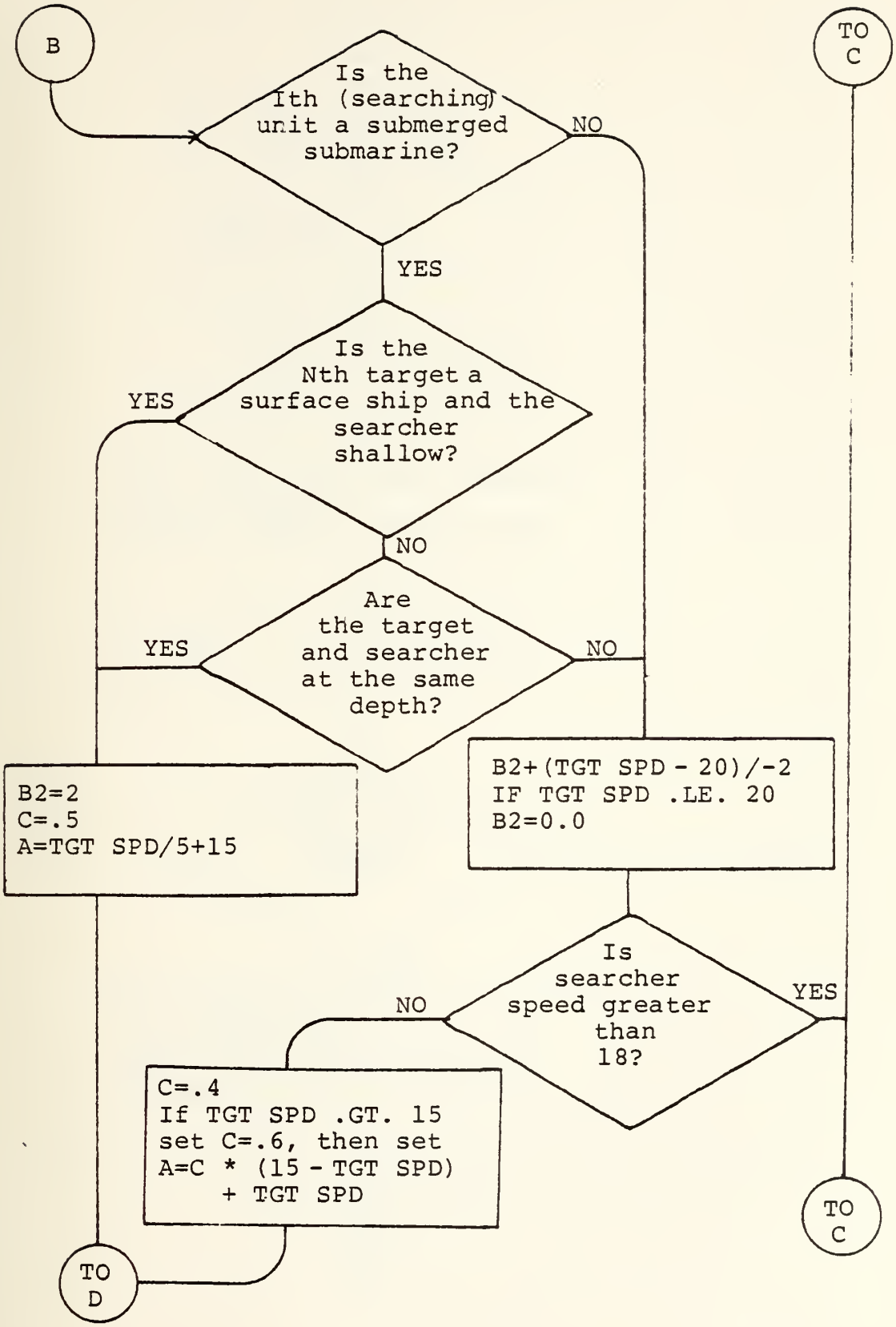
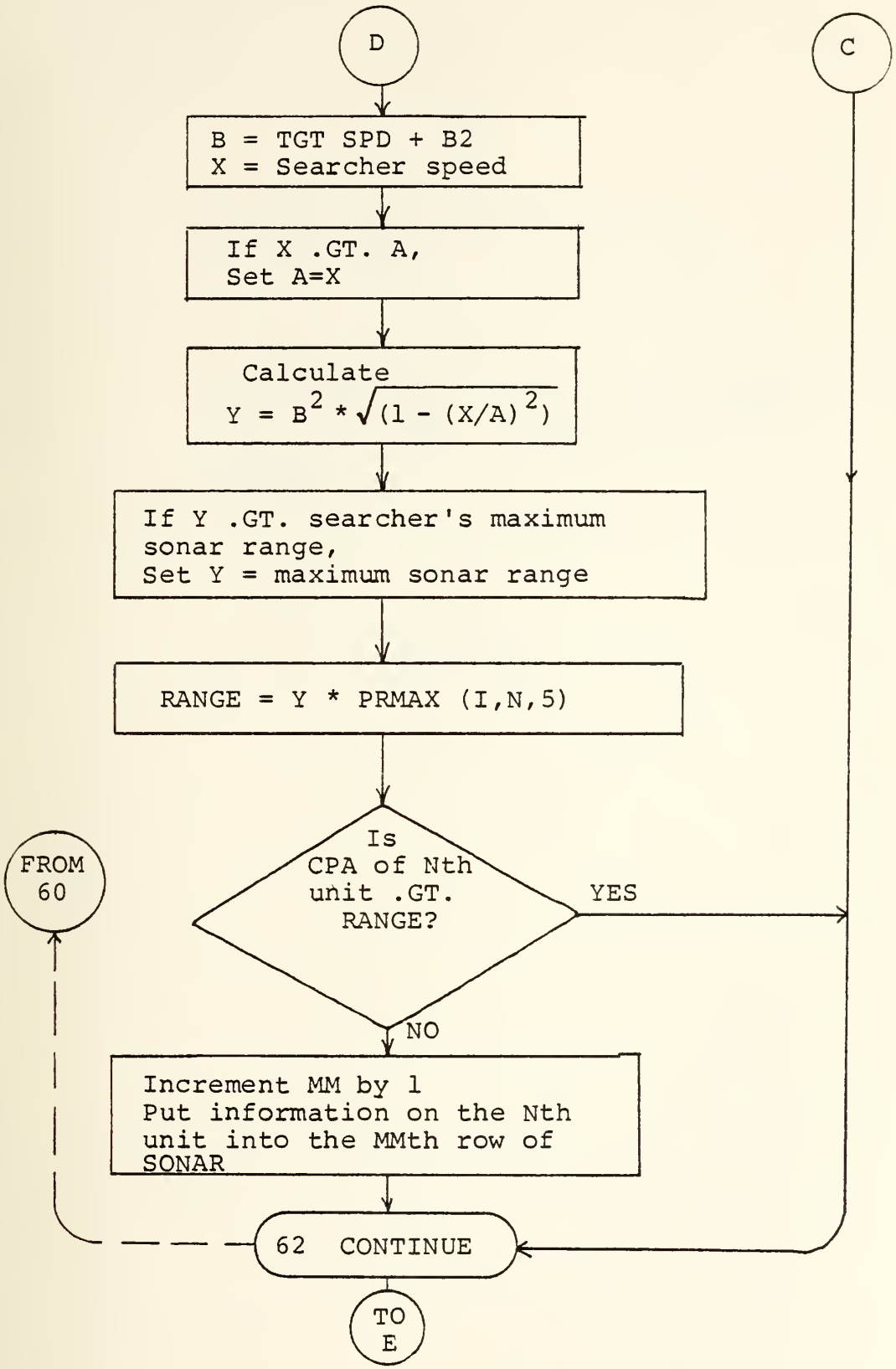


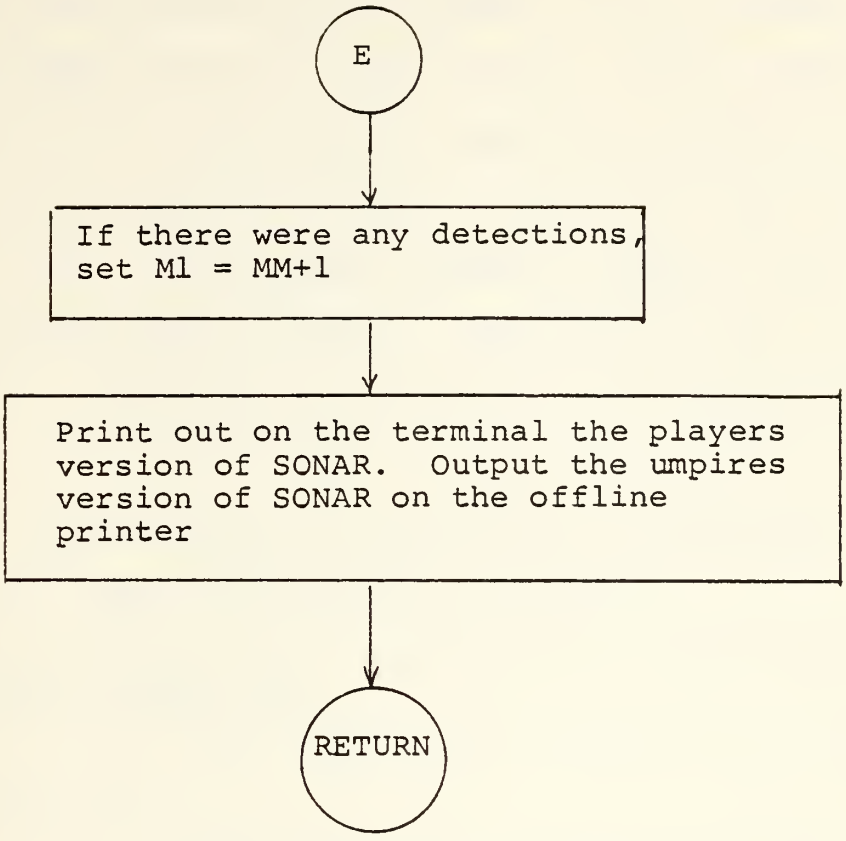
Figure 18

Flowchart of Subroutine PSONAR


A
If there were any detections, output players version of SONAR on the terminal and umpires version on the offline printer
MM=M
For each N=1, NUNIT DO 60
Is the Nth unit out of play?
YES
NO
Calculate NTGT
Is the Nth target an aircraft?
YES
NO
TO B
TO C


B
Is the Ith (searching) unit a submerged submarine?
NO
YES
Is the Nth target a surface ship and the searcher shallow?
YES
NO
Are the target and searcher at the same depth?
YES
NO
B2=2
C=.5
A=TGT SPD/5+15
B2+(TGT SPD - 20)/-2
IF TGT SPD .LE. 20
B2=0.0
Is searcher speed greater than 18?
NO
YES
C=.4
If TGT SPD .GT. 15
set C=.6, then set
A=C * (15 - TGT SPD)
+ TGT SPD
TO C
TO C
TO D


D
C
B = TGT SPD + B2
X = Searcher speed
If X .GT. A,
Set A=X
Calculate
Y = B^2 * √(1 - (X/A)^2)
If Y .GT. searcher's maximum sonar range,
Set Y = maximum sonar range
RANGE = Y * PRMAX (I,N,5)
Is CPA of Nth unit .GT. RANGE?
YES
NO
FROM 60
Increment MM by 1
Put information on the Nth unit into the MMth row of SONAR
62 CONTINUE
TO E


E
If there were any detections, set M1 = MM+1
Print out on the terminal the players version of SONAR. Output the umpires version of SONAR on the offline printer
RETURN

G. DESCRIPTION OF FORTRAN PROGRAM CHANGE

CHANGE allows the player to change a unit's course, altitude or depth and turn radars, sonar, and HF communications on or off. Units may be brought in and out of play by changing their ID. Units brought into play may have their X and Y coordinates changed to insure they enter play at an appropriate location. Units out of play are set to (0,0). CHANGE is executed once per game turn by CASTAG EXEC.

Integer inputs that are incorrect for a particular parameter of a unit are corrected as follows:

1. Speeds greater than listed maximum speed are set to unit's max speed.
2. An altitude other than 0 for a surface unit will be set to 0.
3. Any course greater than 360 will be set to 360.

A unit which has had a non-existent sensor activated will not affect the detection routines. The maximum range for that sensor will be zero in the data base resulting in a consistent zero detection range.

ID numbers and X or Y coordinates are not screened in any way and must be corrected by cycling that particular unit back through the change procedure. Figure 19 is a flowchart of CHANGE and Table 16 is a list of the variables used in CHANGE.

Table 16

List of Variables and Arrays for Program CHANGE

Variable/Array	Description
DATA (50, 20)	Integer array holding either Red or Blue data in the same format as in the data base.
NCOL	Number of columns being used for data in array DATA. Set to 15.
NREAD	Used to designate the terminal as the read device for FORTRAN READ statements. Set to 5.
NWRITE	Used to designate the terminal as the write device for FORTRAN WRITE statements. Set to 6.
NROW	Maximum number of units (rows) array DATA will hold. Set to 50.
ZTIME	Game clock time in minutes. Printed out for reference.
IDENT	Input by user. 1 designates Red; 2 designates Blue.
IDISK	DSRN designating which file to access for information. Set to IDENT + 2, giving 3 for Red, 4 for Blue.
N	Input by user telling the program what column of array DATA will be changed.
ITYPE	Last three digits of Nth units type number.
IDNO	Row subscript of DATA designating that unit will have its ID number changed.
I	Used throughout the program as a variable row subscript for array DATA.
J	Used throughout the program as a variable column subscript for array DATA.

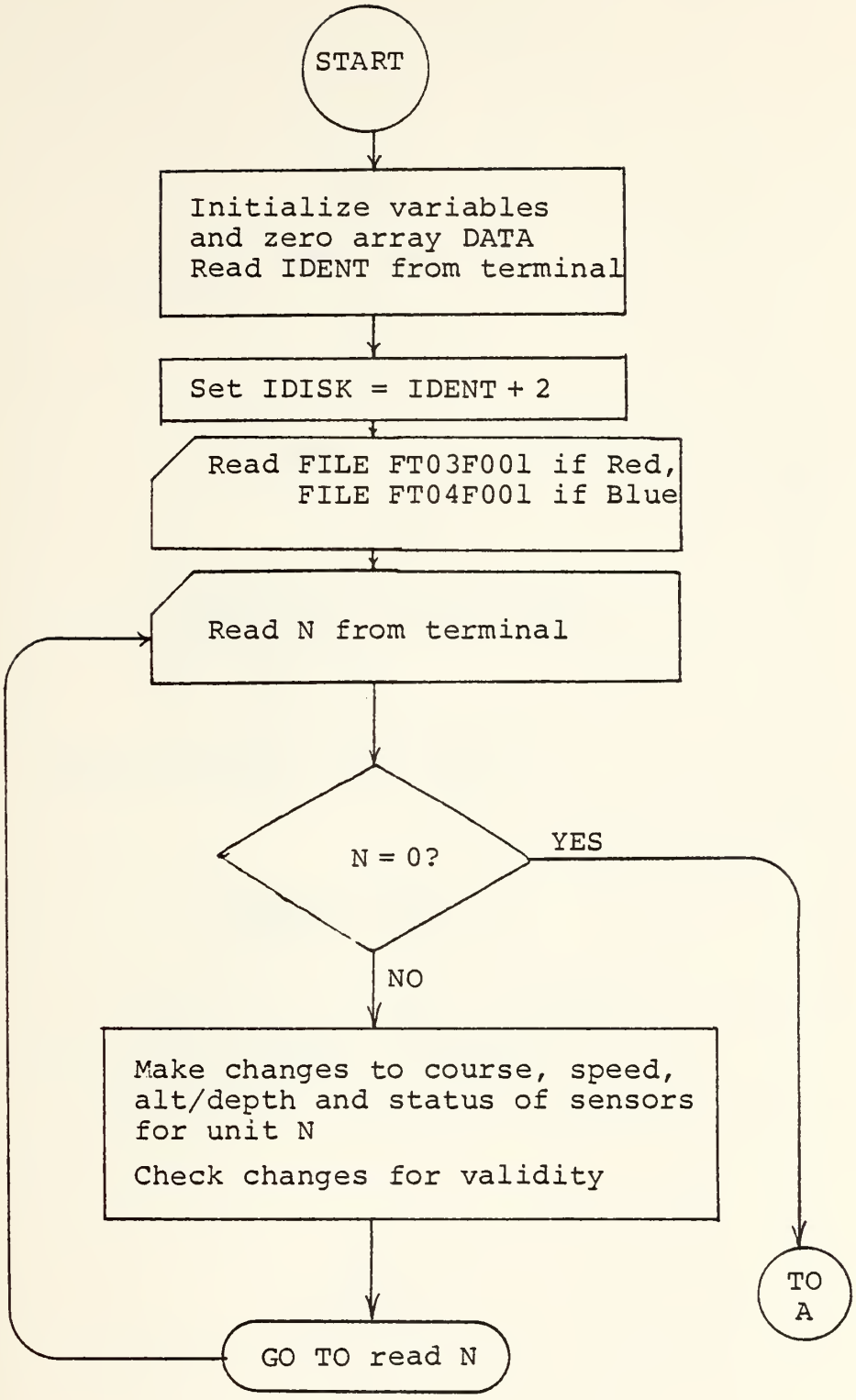
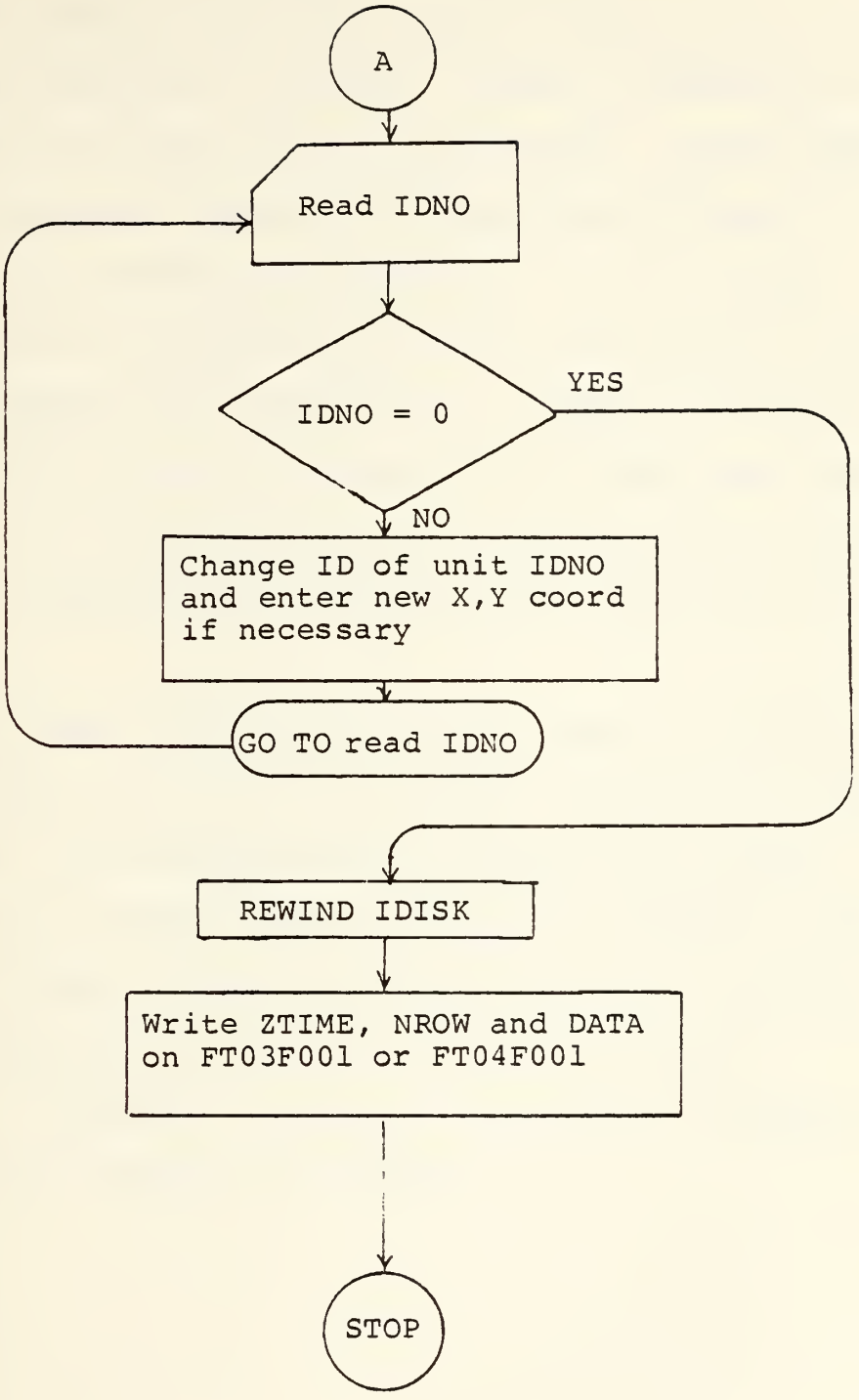


Figure 19

Flowchart of FORTRAN Program CHANGE


A
Read IDNO
IDNO = 0
YES
NO
Change ID of unit IDNO and enter new X,Y coord if necessary
GO TO read IDNO
REWIND IDISK
Write ZTIME, NROW and DATA on FT03F001 or FT04F001
STOP

H. DESCRIPTION OF FORTRAN PROGRAM UPDATE

UPDATE combines two files into the new data base prior to the next execution of SEARCH. UPDATE is executed once at the end of the game turn by CASTAG EXEC. UPDATE READS the two files which contain the user entered changes to the data base (FT03F001 and FT04F001) into two arrays. File FT02F001 is prepared to be written on from the top by a REWIND command which destroys the existing information. File FT02F001 was the data base which had been saved up to this point to provide a backup if either of the two new files were inadvertantly destroyed during execution of CHANGE.

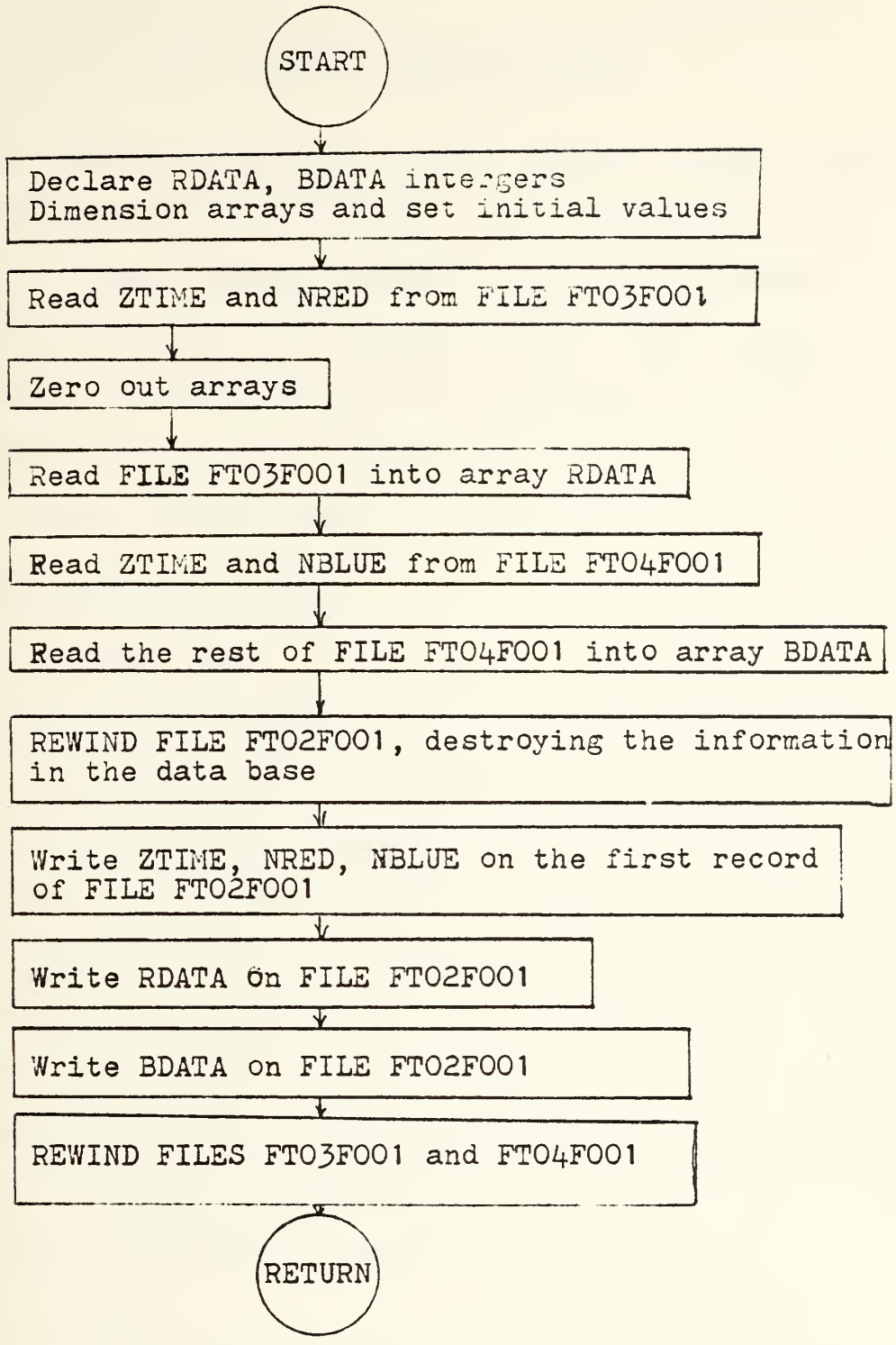
Arrays RDATA and BDATA are written back on FT02F001 in the same format as the old data base. FT02F001 and FT04F001 are rewound. Note that should the users have entered different turn lengths during execution of SEARCH at the terminals, ZTIME will be fixed for next turn at both terminals at whatever was entered by the Blue player.

Table 17 lists the variables and arrays in UPDATE and Figure 20 is a flowchart of UPDATE.

Table 17

List of Variables and Arrays for Program UPDATE

NCOL	Number of columns being used in the data structure. Set to 15.
NROW	Maximum number of units (rows) per side. Set to 50.
NRED, NBLUE	Total number of RED and BLUE units, respectively.
ZTIME	Total game time in minutes.
NDISK	DSRN for the data base. Set to 2 designating file FT02F001 for READ and WRITE statements.
RDISK, BDISK	Integers designating FT03 and FT04 as READ files.
RDATA (50, 20)	RED half of the original data base which has had the changes made.
BDATA (50, 20)	BLUE half of the original data base which has had the changes made.
I	Row subscript for RDATA and BDATA.
J	Column subscript for RDATA and BDATA.


START
Declare RDATA, BDATA integers
Dimension arrays and set initial values
Read ZTIME and NRED from FILE FT03F001
Zero out arrays
Read FILE FT03F001 into array RDATA
Read ZTIME and NBLUE from FILE FT04F001
Read the rest of FILE FT04F001 into array BDATA
REWIND FILE FT02F001, destroying the information in the data base
Write ZTIME, NRED, NBLUE on the first record of FILE FT02F001
Write RDATA on FILE FT02F001
Write BDATA on FILE FT02F001
REWIND FILES FT03F001 and FT04F001
RETURN

Flowchart of FORTRAN Program UPDATE

Figure 20

IV. USER'S GUIDE TO CASTAG

This chapter discusses terminal inputs, program outputs, and program recovery procedures. Some familiarity with SEATAG is assumed as well as some knowledge of FORTRAN format "I" and "F" input type declarations. The line and letter delete instructions refer specifically to the DECWRITER T-300 terminals in the NPS Computer Center. Other terminals should have analogous functions.

A. CASTAG TERMINAL INPUTS

The terminals have two keys which can be used to correct input errors before returning the carriage. The "@" symbol is used to delte the previous character in an input line. More than one "@" can be used per line. For example, entering a format 1I2 parameter, "1A" is typed. To correct the illegal character "A", type "@2" resulting in "1A@2" which will be read as "12" following the carriage return. The "]" symbol typed at the end of a line will cause the terminal to delete the line following the carriage return allowing the user to re-enter the line.

To begin execution of CASTAG, enter:

```
$ CASTAG
```

the terminal will print:

```
THIS IS THE SEATAG EXEC ROUTINE.
  THIS PROGRAM WILL REQUIRE A DATA BASE
WHICH HOLDS ALL THE APPROPRIATE SHIP AND
AIRCRAFT CHARACTERISTICS.
```

```
ENTER THE USER NUMBER OF THE OTHER PLAY INCLUD-
ING P OR G FOR USER TYPE, MAKING A TOTAL OF 5
 DIGITS, EG; "1059P".
>
```

The ">" symbol means the terminal is waiting for an input to CASTAG EXEC. An illegal input will cycle an EXEC program back to the input instruction. In this example, the user entered "1059P". The terminal replies with:

```
IS OTHER PLAYERS ID = 1059P ? ENTER Y OR N.

>Y
```

Answering with "N" would give the user a chance to re-enter the user ID. Following a "Y" entry, the terminal prints:

```
FILE FT02F001 IS THE DATA BASE.  THIS FILE MUST BE
SENT TO THE CONSOLE OF THE OTHER PLAYER IF NO COPY
EXISTS IN HIS FILES.  IF YOU ARE THE OTHER PLAYER,
YOU WILL HAVE TO READ FILE FT02F001.
IF NO TRANSFER OF DATA BASE REQUIRED ENTER N.
TO TRANSFER DATA BASE TO OTHER PLAYER ENTER "T".
TO READ THE DATA BASE FROM THE OTHER PLAYER ENTER "R".
>R
```

The example shows the user wants to read the data base from the other terminal.

```
FILES:- NO RDR, NO PRT, NO PUN
IF YOU HAVE A FILE SPOOLED WAITING TO BE READ,
ENTER "Y".  IF NOT ENTER ANY OTHER LETTER EXCEPT N.
THE PROGRAM WILL CONTINUE TO RETURN HERE UNTIL THE
FILE IS AVAILABLE OR UNTIL Y OR N IS ENTERED.  TO
GO AHEAD WITHOUT READING THE FILE ENTER N.
```

The message shows no files waiting to be read. Consequently, an entry of any letter except "Y" or "N" should be made. Either or both of the messages will indicate that there is a spooled file waiting. These are:

```
** CARDS XFERED BY 1059P05 **
```

or

```
FILES:- 01 RDR, NO PRT, NO PUN
```

Assuming the user had entered "N", and then received one of the two messages above, the terminal repeats:

```
IF YOU HAVE A FILE SPOOLED WAITING TO BE READ,
ENTER "Y".  IF NOT ENTER ANY OTHER LETTER EXCEPT N.
THE PROGRAM WILL CONTINUE TO RETURN HERE UNTIL THE
FILE IS AVAILABLE OR UNTIL Y OR N IS ENTERED.  TO
GO AHEAD WITHOUT READING THE FILE ENTER N.
>y
```

Entry of "Y" will output a verification of the file read:

```
OFFLINE READ     FILE      FT02F001 P1
```

An entry of "T" will print one message:

```
**  CARDS XFERED TO 0000G **
```

and skip the preceding sequence.

Entry of "N" at any point skips the file transfer section and proceeds with program execution, even if there is no data base at one or both terminals.

The next line, "EXECUTION BEGINS. . ." indicates the start of a FORTRAN program. In this case it is program SEARCH. All inputs to FORTRAN programs will have format instructions for the required entry. All are integer entries with the exception of one F4.0 entry. Integer formats are specified by "FORMAT I4" or "1I2" or "1I1" or some combination thereof. Any illegal entries will cause either program termination or a "fix-up" which will probably cause the input to be read as zeros.

SEARCH requires three entries. The first is the random number seed, of up to seven integers. A zero may be entered

in which case the program sets the random number seeds. Different random number seeds should be entered at the two terminals. The next entry is the duration of the next turn in minutes. Both terminals should enter the same value. The maximum value is 1440 minutes or 24 hours and the minimum is zero. Only the time specified by the Control Group should be entered. Last, a single digit entry, "1" or "2", tells the program whether it is Red or Blue. Following these entries, a printout of detection information for each side is printed out at the terminal. Interpretation of this output is covered in Section B of this chapter. Below is an example of the inputs to SEARCH:

```
EXECUTION BEGINS...
 ENTER  THE RANDOM NUMBER SEED, FORMAT I7.

>1219503
 ENTER THE  TIME, IN MINUTES, OF THIS TURN, F4.0.
>60
 ENTER "1" IF YOU ARE THE RED PLAYER, "2" IF BLUE.
 FORMAT 1I1.

>2
```

The entries show a seed of "1219503", a sixty minutes turn length and that this terminal is Blue this turn.

Conclusion of program SEARCH and the start of the next FORTRAN program is indicated by

```
"EXECUTION BEINGS...
ENTER 1 FOR RED, 2 FOR BLUE, FORMAT 1I1".
```

The next FORTRAN program, CHANGE, has begun execution. This is an interactive sequence that allows the user to change parameters and bring units in and out of play. The initial access is by row, so the first unit in the data base is

unit "1". There can be up to 50 units so these entries are made in I2 format. A code number (2 through 8) is input to determine which value is to be changed followed by the new value when requested. All changes to a unit should be made first before moving on to another unit although it is possible to cycle through the changes as many times as required. Appendix B provides an example of an actual CHANGE execution.

Following entry of the last change to the last unit, program control is returned to CASTAG EXEC. The next sequence transfers the files altered by CHANGE.

```
NOW EACH PLAYER  SENDS HIS  UPDATED FILE TO THE OTHER
   PLAYER.  TO INITIATE TRANSFER,
ENTER "R" IF YOU ARE RED, "B" IF BLUE.
>b
YOU ENTERED B . IS THIS CORRECT? ENTER "Y" OR "N".
>w
```

The above sequence tells the CASTAG program if it is Red or Blue.

Two messages will indicate a file waiting to be read as in the data base transfer.

```
** CARDS  XFERED BY 1059P05 **
** CARDS  XFERED TO 1059P   **
FILES:- 01 RDR, NO PRT, NO PUN
DO YOU HAVE A FILE SPOOLED TO BE READ? ENTER "Y" OR "N".
>y
OFFLINE READ      FILE     FT03F001 P1
```

The XFERED BY" message mau appear while still executing CHANGE. This means the other terminal user has finished his changes and initiated transfer. The other player still must wait to read your change file before continuing. The rest of the

sequence is carried out as if "R" was entered in the transfer at the beginning of the program.

After both transfers have been completed, a list of files is output for comparison to four filetypes. Each terminal should have all four before proceeding to the next turn.

```
FILENAME FILETYPE MODE NO.REC. DATE
FILE     FT01F001  P1     10    2/19
FILE     FT02F001  P1      2    2/19
FILE     FT04F001  P1      1    2/19
FILE     FT03F001  P1      1    2/19
YOU SHOULD HAVE FILE TYPES FT02F001, FT03F001, FT04F001
    AND FT01F001 ON YOUR DISK AT THIS TIME.
```

CASTAG executes UPDATE and prints:

```
TO PLAY ANOTHER TURN, ENTER Y.  TO QUITE ENTER N.
```

This entry lets the user go back to SEARCH to play another turn or to terminate the program.

B. DECODING/ENCODING TYPE NUMBERS

Each unit in CASTAG is given a four digit code for identification as to the unit's side, platform, kind and class. These numbers are called type numbers and are assigned when the data base is created. They are decoded by the participants to determine information about specific detections. Table 18 provides definitions for the first three digits. Table 19 gives the fourth digit assignment for all the units currently available in CASTAG.

Table 18

First Three Digits of Type Number Assignment

DIGIT	NAME	VALUES	DEFINITION
First	Side	0	Neutral
		1	Red
		2	Blue
Second	Platform	1	Submarine
		2	Aircraft/helicopter
		3	Surface vessel
Third	Kind	0	Merchant or civilian
		1	Submarine
		2	Aircraft carrier
		3	Large surface combatant (CG,CLG,DDG)
		4	Small surface combatant (FF,FFG, PG)
		5	Service force/ amphibious force (AOE)
		6	Fighter, Interceptor, Attack Aircraft
		7	ASW fixed wing aircraft (S-3,P-3)
		8	Bomber, Recon or AEW aircraft
		9	Helicopter

Table 19

Type Numbers, Fourth Digit

BLUE UNITS	NUMBER	CLASS
Submarines	1	Los Angeles
	2	Sturgeon
Aircraft carrier	1	USS America
CG, CLG, DDG, DD (Largest surface combatants)	1	Leahy
	2	C. F. Adams
	3	Coontz
	4	Barry
	5	Spruance
FF, FFG, PG, PGM (Small surface combatants)	1	Perry
	2	Brooke
	3	Knox
	4	Garcia
Service force/Amphibious	1	Sacramento
Fighter/Attack aircraft	1	KA-6D Tanker
	2	EA-6B ECM support
	3	A-6 Corsair
	4	A-7 Intruder
	5	Phantom II
ASW fixed wing aircraft	1	S-3A
	2	P-3C
Bomber, Recon, AEW aircraft	1	E-2C
Helicopters	1	SH-3H
	2	SH-2D

Table 19 (Continued)

RED UNITS	NUMBER	CLASS
Submarines	1	Charlie SSGN
	2	Victor SSN
	3	Echo II SSGN
	4	November SSN
	5	Juliett SSG
	6	Foxtrot SS
Aircraft carriers	1	Kiev
	2	Moskva
CG, CLG, DDG, DD	1	Kara
	2	Kresta I Kynda
	3	Kresta II
	4	Krivak
FF, FFG, PG, PGM	1	Nanuchka
Service/Amphibious force	1	Chilikin (AOE)
Fighter/Attack aircraft	1	MIG 23
	2	YAK 36 Forger
ASW fixed wing		None
Bomber/Recon aircraft	1	Bear
	2	Badger

C. CASTAG TERMINAL OUTPUT

Following execution of SEARCH, the detection information for that side is output on the terminal. If there were no detections by a particular unit or no detections of a certain type there is no output. It is possible for there to be no detections, and hence no output, at all. All detections, with the exception of active sonar, are of opposing units.

The first output is surveillance information available only at 0001, 0601, 1201 and 1801 game time. The information is presented as follows:

UNIT TYPE	X-COORD	Y-COORD	PLATFORM	COURSE
21	535	476	0	0
23	504	491	47	95

Unit type is the first two digits for the type number. In the example above, "21" is a Blue submarine and "23" is a Blue surface unit. The (X,Y) position is the current one. The platofrm is the last two digits of the type number. "0" indicates the information is not available. The course, if provided, is rounded to within 10 degrees of the true course.

Any HF detections are output next in the following format:

HF DETECTIONS OF ENEMY COMMS

X COORD	Y COORD
510	510

This example informs the user there was an enemy HF transmission originating from (510, 510) during this turn.

Each unit, in row order, will now have all of its detections printed. The output order varies with the platform as shown below:

ORDER	SUBMARINE	SURFACE	AIRCRAFT
1	Passive Sonar	ESM	Visual
2	ESM	Visual	ESM
3	Radar	Radar	Radar
4	Visual	Passive Sonar	Active Sonar
5	Active Sonar	Active Sonar	N/A

Passive sonar detections have the following format:

```
DETECTIONS OF ACTIVE SONARS BY UNIT 111
   DEPTH   BEARING   APPROX RANGE
     0        89          10

PASSIVE DETECTIONS BY UNIT1011
    COURSE  SPEED   DEPTH    RANGE  BEARING
     160      30       0       12     89
     100       7       1        2    199
```

Course, speed, and depth are as per the information in the data base. The bearing is in both cases the bearing at CPA, not necessarily the most current bearing. The passive detection range is the range at CPA. The approximate range for ESM detections of active sonars is a uniformly distributed random variable with the mean at the range at CPA. These detections are by unit ID number 111.

All ESM detections appear in the following format:

```
ESM INTERCEPTS BY UNIT  333
       RADAR    BEARING   PLATFORM
         13        91        33
         12        26        29
RADAR TYPE 12 = SURFACE SEARCH TYPE 13 = AIR SEARCH
```

In the above example unit 333 has detected an air search radar (type 13) and a surface search radar. Both bearings are the radar bearings at CPA. The platform number is the middle two digits of the type number. "33" represents a Red CG/CLG and "29" is a Red helo.

Air and surface search radar detections appear jointly by unit. In the following example, unit 666 has detected two targets. The "12" designates the S/S radar and "13" the A/S radar. Notice that although the air target has a speed of 10 knots it must still be an air target of some type. It could be a helicopter of an aircraft presumed to be orbiting. "COMP" is the number of targets in the unit or its composition. All detections are single targets so this information is superfluous.

RADAR DETECTIONS BY UNIT 666

RADAR TYPE	COURSE	X COORD	Y COORD	SPEED	COMP.
12	160	547	448	10	1
13	225	510	510	10	1

Active sonar detections may be either friendly or enemy submarines. An example of a detection printout is provided below.

ACTIVE SONAR DETECTIONS BY UNIT 50

DEPTH	COURSE	X COORD	Y COORD	SPEED
1	95	535	473	10
1	100	534	472	7

Unit 50 has detected two submarines in close proximity. A depth of "1" indicates they are both shallow while a "2" would indicate deep. (X,Y) position, course and speed are as previously explained.

Visual identifications, although only occurring at short range, provide reasonably complete target identification. In the example provided, unit 333 has two detections. Complete type information identifies "1332" as a Red CG of the KARA class. "1293" is a KA-25 Hormone helicopter. The altitude in the helicopter's case is 1000 feet. Bearing is still the bearing at CPA. The rest of the information is self explanatory.

VISUAL DETECTIONS BY UNIT 333

TYPE	ALT	COURSE	X COORD	Y COORD	BEARING	COMP
1332	0	245	419	479	355	1
1293	1	255	497	476	244	1

An example of the terminal output for every kind of detection has been provided. This information is in fact what the players will be basing their tactical decisions on. Section D provides a similar discussion of the offline printer output.

D. CASTAG OFFLINE PRINTER OUTPUT

Each terminal prints five sections in order. Each section is usually no more than a page in legnth. The contents and use of each section is discussed in order of appearance.

A representative form the Control Group should collect the printouts and distribute sections two and three to their respective sides. Both copies of Sections one, four, and five should go to the Control Group.

1. Umpire Summary of Detections

This output matches that of each terminal with the same detections in the same order as the originating terminal. The Control Group will need one from each terminal to get a complete picture of the preceding turn. All the information on the terminal printout is present with the addition of the ID number of the unit detected, the range and bearing of CPA and other pertinent information. The CPA range is especially important for playing engagements as this will be the range for all firing calculations. An example of the information provided in this printout is reproduced below.

```
 UMPIRE COPY, PASSIVE SONAR DETECTIONS, UNIT   51
    ID  SPD DEPTH   CSE  X    Y   TYPE  RGE  BRG
   555   17    0     90  548  491 2347    5   60

UMPIRE VERSION OF VISUAL SIGHTINGS, UNIT   71
  TYPE    ALT. COURSE X COORD Y COORD BRG  COMP  CPA  RNG  ID
  2333     0    90        513     480   67    1     11    333

 ESMDET, UMPIRE VERSION ID = 71
     RADAR  BEARING  PLATFORM ID NO. CPA RANGE
       12       88       32      444       25
       13       88       32      444       25
       13       70       34      555       45
       13      101       34      666       71
RADAR TYPE 12 = SURFACE SEARCH TYPE 13 = AIR SEARCH

UMPIRE VERSION OF RADAR DETECTIONS, UNIT   71
    ID  TYPE RADAR   CSE  X GRID Y GRID SPEED COMP CPA RGE & BRG
   333  2333    12    90   513   480    11     1        11    67
```

2. Red/Blue Cartesian Plot

For each terminal, a plop of all the side's forces in a 1000 by 1000 mile cartesian plot in the positive quadrant is provided. All detections which specified an (X,Y) position

are also plotted on this page. The two sides' units are plotted with different symbols ("+" and "."). This is distributed to the players.

3. Status of Forces Table

Each side receives page 3 which lists their forces and the current game time in hours and minutes. An example is provided below:

STATUS OF FORCES AS OF 8 HRS. 30 MIN

UNIT ID	SPEED KTS	DEPTH /HT	COURSE DEG T	X GRID	Y GRID	TYPE	MAX SPD	MAX S/S	MAX A/S	MAX SNR
50	30	0	265	476	478	1332	34	25	150	10
51	10	0	265	530	488	1333	35	20	150	10
52	10	0	265	532	448	1346	34	20	150	10
60	7	1	100	555	467	1110	30	100	0	30
0	0	20	90	900	500	1281	450	200	0	0
71	10	1	225	493	472	1293	120	30	30	2

The last four columns are the maximum speed and sensor ranges for the unit in question. Note that the fifth is out of play.

4. Umpire's Cartesian Plot

A plot of all the units in the game including those out of play is provided on each terminal's output. The format is the same as that for the players. The copies from both terminals should be identical. Two are provided for the convenience of the Control Group.

5. Data Base Printout

File FT02F001 is printed out on each terminal as it appears following the execution of TURN but without the updating accomplished in the CHANGE program. Each terminal's copy should be identical. Both copies are provided for Control Group use.

E. PROGRAM FAILURES

Only two kinds of program failures should occur in CASTAG. Either a data entry error in the interactive phases or a CP/CMS shutdown may cause termination of the program. The critical consideration in restarting CASTAG is that both programs in two different terminals must be kept executing together. Suggestions for dealing with some of the various possibilities are provided in this section.

1. Data Entry Error

Data entries to the EXEC routine cannot normally cause termination as illegal entries cycle the program back to the input statement. Entry of the wrong side, i.e., "R" vice "B" or wrong user ID will prevent any file transfers. To recover, terminate the EXEC and manually make the required transfer. Next turn the programs can be restarted together.

Although only three entries are required for SEARCH, these may have the most damaging effect as some illegal character entries are read as zero. If the TURN program terminates, the CASTAG EXEC may be restarted. "1" and "2" are the only entries accepted for Red/Blue terminal designation. Should both terminals enter the same number, stop execution and restart execution with "CASTAG EXEC". A time of zero will cause no movement or detections and again, the program may be restarted. The worst case is if the programs start with two different times. The original data base will be irrevocably changed to reflect movement. Short

of retyping the data base the only solution is to have the terminal with the shorter time execute SEARCH for the difference. The only effect on the game would be one more HFDF segment for the terminal executing twice.

CHANGE is where most errors usually occur due to the large number of entries required. All entries to CHANGE with the exception of the first may be changed again and again until the user terminates the program. The first entry which tells the program if it is Red or Blue will cause an error if the number does not match that entered in SEARCH. If CHANGE does terminate, it can be restarted with "CHANGE". The rest of the EXEC will have to be done manually until it is time to start the next turn. Then CASTAG EXEC can be restarted to get both terminals back together.

2. CP/CMS Failure

When a CP/CMS failure occurs, immediately check to see what condition file FT02F001 (the data base) is in. If both terminals were exactly in step and CP/CMS went down just after the file was rewound on both terminals but before the information was written back on the file, the data base will be lost.

Assuming the data base is intact on one terminal, execute CASTAG from the top utilizing the data base transfer section. The critical consideration is that both terminals always start from identical data bases.

V. FUTURE DEVELOPMENT AND RESULTS

A. IMPROVEMENTS AND EXTENSIONS OF CASTAG

Future work on CASTAG falls into three major categories. First, there is the inclusion of those parts of SEATAG not programmed. Second is improvements to facilitate play and umpire functions of the part of the game now covered. Last, improvements to the program to use less core and improve programming efficiency should be considered.

1. Tactical Improvements

In SEATAG, surface units with two air search radars are given no more capability than a unit with only one. Units with the dual capability should have some kind of enhanced detection capability against air targets.

The time constraint forced the omission of sonobuoy fields for ASW aircraft. These are treated as static detection areas in the game with a different detection methodology. Currently, they could be played manually in conjunction with CASTAG by the Control Group.

To make CASTAG a complete game requires the programming of the SEATAG engagement and damage methodology. In the author's opinion, an effort approximating the work done on this project would be required to accomplish this.

2. Display and Bookkeeping Improvements

The Control Group is required to monitor aircraft and diesel submarine time on station to prevent unrealistic

mission lengths. Time on station or time submerged could easily be kept in one of the unused columns of the DATA array.

To facilitate play of aircraft, the SEATAG aircraft carrier packages would speed play and reduce the number of units devoted to air assets. If the Blue player wants to use the SEATAG CV around the clock defensive package with a strike or cap surge, he will have to operate fifteen plus aircraft. The CV begins to approach the program limit of total units in a carrier strike warfare environment. In conjunction with programming the packages, multiple units where 10 strike aircraft would be one unit of composition 10 would be introduced.

The 1000 by 1000 mile plots should be made variable so the players can enter a midpoint and radius to designate the plot limits. Since most engagements take place at ranges less than 100 miles, a smaller scale output centered around the area of interest would be an improvement.

The player output should include a current range calculation whenever the (X,Y) position is given. As it now stands, the players have to make this determination themselves.

3. Programming Improvements

The input screening and interactive sequences have ample room for improvement. Some could be eliminated, particularly two of the three inputs telling the terminal whether it is Red or Blue.

The arrays RADAR, SONAR, ESMDET, INTELL and HFDF are redundant. Their function could have been handled by one array.

There are, no doubt, other inefficiencies the discerning programmer could spot.

B. RESULTS

The SEATAG Documentation suggests lunch breaks and related lectures as a way to utilize the time the two sides will spend waiting for the umpires to finish. This is an example of the principal difficulty with a manual wargame, the time factor.

CASTAG reduces the time to play a turn of SEATAG to less than fifteen minutes. All of the time saved comes from what was essentially idle time for the players while the Control Group plotted the moves. The game can be used as is in the various wargaming courses extant at the Naval Postgraduate School and perhaps elsewhere.

APPENDIX A

ADDITIONAL UNITS

Ship Class/Aircraft Name: KRESTA I (4) — RED/~~BLUE~~/ Title: CLG

CHARACTERISTICS	SENSOR	FUNCTION	RANGE * (nm) Good	RANGE * (nm) Bad	SENSOR	FUNCTION	RANGE * (nm) Good	RANGE * (nm) Bad
FLD/MTOW(T): 8000	DON	SURF RADAR	20	15	PEEL GRP	(2) MFCS	-	-
L(ft): 510	HEAD NET	C AIR RDR	150	75	MUFF COB	(2) GFCS	-	-
W/B(ft): 56	BIG NET	AIR RADAR	150	75	BASS TILT	(2) GFCS	-	-
D/H(ft): 20	PLINTH NET	?			SCOOP/	(1) SSM/MFCS	-	-
Ceiling(kft):					PAIR			
Spd: Max(kt): 35	SONAR	ASW	10	2				
Cruise(kt):								
Patrol(kt): 18								

WEAPONS	FUNCTION	# LAUNCHERS or MOUNTS	# BARRELS, RAILS PER SYS	TOTAL WPNS	RANGE * (nm) Min	RANGE * (nm) Max
SS-N-3	ASUW/SSM	2	2	4	2	30#
SA-N-1	AAW/SAM	2	2	60	2	16
57mm GUN	AAW	2	2	1000	0	3
20mm GUN	ASMD	4	-	2000	0	1
MBU2500	ASW		12	48	0	3
MBU4500	ASW	2	6	24	0	1
21"TT	ASW/ASUW	2	5	10	2	10
	#170 NM	WITH EXTERNAL TARGETING				
1	HORMONE A/B	HELICOPTERS				

Mission Time(hr): 20 day
Endurance at Cruise(nm): 5500

Remarks: 4 BOILERS TURBINES-2 100,000 SHP

NOTES: * These notional values are not necessarily precise. They are considered representative and provided for game purposes only.

"COST" 50 TOKENS

Ship Class/Aircraft Name: KYNDA CLASS (4) — RED/BLUE Title: CLG

CHARACTERISTICS	SENSOR	FUNCTION	RANGE * (nm) Good	RANGE * (nm) Bad	SENSOR	FUNCTION	RANGE * (nm) Good	RANGE * (nm) Bad
FLD/MTOW(T): 5700	DON	SURF RADAR	20	15	SCOOP/	(2) SSM/	-	-
L(ft): 468	HEAD NET	A AIR RDR	150	75	PAIR	MFCS		
W/B(ft): 52	SONAR	ASW	10	2	PEEL/	(1) SAM/	-	-
D/H(ft): 17					GROUP	MFCS		
Ceiling(kft):					OWL/	(1) 76mm	-	-
Spd: Max(kt):					SCREECH	GFCS		
Cruise(kt):								
Patrol(kt):								

WEAPONS	FUNCTION	# LAUNCHERS or MOUNTS	# BARRELS, RAILS PER SYS	TOTAL WPNS	RANGE * (nm) Min	RANGE * (nm) Max
SS-N-3	ASUW/SSM	2	4	16	2	30#
SA-N-1	AAW/SAM	1	2	30	2	16
76mm GUN	AAW	2	2	1000	0	5
MBU2500	ASW	1	12	24	0	3
21" TT	ASW/ASUW	2	3	12	2	10
	#170 NM WITH EXTERNAL TARGETING					

Mission Time(hr): 15 day
Endurance at Cruise(nm): 7000

Remarks: 4 BOILERS 2 TURBINES 100,000 SHP

NOTES: * These notional values are not necessarily precise. They are considered representative and provided for game purposes only.

"COST" 40 TOKENS

APPENDIX B

CHANGE OUTPUT

```
EXECUTION BEINGS...
ENTER 1 FOR RED, 2 FOR BLUE, FORMAT 1I1.

>1
IT IS   360. Z TIME, YOU HAVE    6 UNITS.
ENTER THE ROW NUMBER OF THE UNIT YOU WISH TO CHANGE THE
STAUTS OF, 1I2, "0" WILL INDICATE NO CHANGES TO ANY UNIT.

>03
CODE    UNIT ID=  52
  2     SPEED IS   10 KIS.
  3     ALT/DEPTH=   0*10**3 / 1=SHALLOW,2=DEEP.
  4     COURSE is   80 T.
  5    SURFACE SEARCH RADAR:  0  1=ON.
  6    AIR SEARCH RADAR:      0 0=OFF.
  7              SONAR:     0
  8    HF COMMUNICATIONS:   0
ENTER THE CODE NUMBER OF THE LINE YOU WANT TO CHANGE,
1I1.  " 0" MEANS NO CHANGES TO THIS UNIT.

>5
ENTER THE NEW VALUE FOR CODE NO. 5, 1I4.

>0001
CODE    UNIT ID=  52
  2     SPEED IS   10 KTS.
  3     ALT/DEPTH=   0*10**3 / 1=SHALLOW,2=DEEP.
  4     COURSE IS   80 T.
  5    SURFACE SEARCH RADAR:   1   1=ON.
  6    AIR SEARCH RADAR:       0  0=OFF.
  7              SONAR:     0
  8    HF COMMUNICATIONS:   0
ENTER THE CODE NUMBER OF THE LINE YOU WANT TO CHANGE,
1I1.  " 0" MEANS NO CHANGES TO THIS UNIT.

>0
IT IS   360. Z TIME, YOU HAVE   6 UNITS.
ENTER THE ROW NUMBER OF THE UNIT YOU WISH TO CHANGE THE
STATUS OF, 1I2, "0" WILL INDICATE NO CHANGES TO ANY UNIT.

>0
IF YOU WISH TO BRING AN OUT OF PLAY UNIT
INTO PLAY OR PUT A UNIT OUT OF PLAY ( I.E. SINK IT),
ENTER THE ROW NUMBER OF THAT UNIT, 1I2. "0" MEANS
NO UNITS TO PUT IN OR OUT OF PLAY.

>05
```

```
CODE   UNIT ID=    0
  2    SPEED IS     0 KTS.
  3    ALT/DEPTH=  20*10**3 / 1=SHALLOW,2=DEEP.
  4    COURSE IS   90 T.

ENTER THE NEW UNIT ID ,1I4.  "0" PUTS THE UNIT
OUT OF PLAY.  ANY OTHER VALUE BRINGS THE UNIT INTO
PLAY WITH THAT ID NUMBER.

>0077
UNIT  5 IS NOW AT   900  500
ENTER FORMAT I4 FIRST  THE NEW X COORDIANTE
THEN, AFTER THE SECOND   APPEARS, THE NEW Y COORDINATE.

> 100
> 100
IF YOU WISH TO BRING AN OUT OF PLAY UNIT
INTO PLAY OR PUT A UNIT OUT OF PLAY ( I.E. SINK IT),
ENTER THE ROW NUMBER OF THAT UNIT, 1I2. "0" MEANS
NO UNITS TO PUT IN OR OUT OF PLAY.

> 3
CODE    UNIT ID=  52
  2     SPEED IS   10 KTS.
  3     ALT/DEPTH=  0*10**3 / 1=SHALLOW,2=DDEP.
  4     COURSE IS   80 T.

ENTER THE NEW UNIT ID ,1I4.   "0" PUTS THE UNIT
OUT OF PLAY.  ANY OTHER VALUE BRINGS THE UNIT INTO
PLAY WITH THAT ID NUMBER.

>0
IF YOU WISH TO BRING AN OUT OF PLAY UNIT
INTO PLAY OR PUT A UNIT OUT OF PLAY ( I.E. SINK IT),
ENTER THE ROW NUMBER OF THAT UNIT, 1I2, "0" MEANS
NO UNITS TO PUT IN OR OUT OF PLAY.

>0
R; T=0.92/2.63 10.38.02

>
```

```
&TYPEOUT OFF
GLOBAL T SYSLIB INSLSP SSPLIB
&LPRINT  THIS IS THE SEATAG EXEC ROUTINE.
&UPRINT    THIS PROGRAM WILL REQUIRE A DATA BASE
&UPRINT  WHICH HOLDS ALL THE APPROPRIATE SHIP AND
&UPRINT  AIRCRAFT CHARACTERISTICS.
&UPRINT
-MSG2 &PRINT ENTER THE USER NUMBER OF THE OTHER PLAYER INCLUD-
&UPRINT ING P OR G FOR USER TYPE, MAKING A TOTAL OF 5
&UPRINT  DIGITS, EG: "1059P".
&READ ARGS
&ID = &1
&ERROR &CONTINUE
&PRINT IS OTHER PLAYERS ID = &ID ? ENTER Y OR N.
&READ ARGS
&IF &1 NE Y &GOTO -MSG3
&UPRINT FILE FTO2F001 IS THE DATA BASE. THIS FILE MUST BE
&UPRINT SENT TO THE CONSOLE OF THE OTHER PLAYER IF NO COPY
&UPRINT EXISTS IN HIS FILES.  IF YOU ARE THE OTHER PLAYER,
&UPRINT YOU WILL HAVE TO READ FILE FTO2F001.
-MSG4 &PRINT IF NO TRANSFER OF DATA BASE REQUIRED ENTER N.
&UPRINT TO TRANSFER DATA BASE TO OTHER PLAYER ENTER "T".
&UPRINT TO READ THE DATA BASE FROM THE OTHER PLAYER ENTER "R".
&READ ARGS
&IF &1 EQ T &GOTO -TRANS
&IF &1 EQ N &GOTO -MSG5
&IF &1 NE R &GOTO -MSG4
-FILERD &CONTINUE
CP QUERY F
&PRINT IF YOU HAVE A FILE SPOOLED WAITING TO BE READ,
&PRINT ENTER "Y". IF NOT ENTER ANY OTHER LETTER EXCEPT N.
&UPRINT THE PROGRAM WILL CONTINUE TO RETURN HERE UNTIL THE
&UPRINT FILE IS AVAILABLE OR UNTIL Y OR N IS ENTERED. TO
&UPRINT GO AHEAD WITHOUT READING THE FILE ENTER N.
&READ ARGS
&IF &1 EQ N &GOTO -MSG5
&IF &1 NE Y &GOTO -FILERD
O READ *
&GOTO -MSG5
-TRANS &CONTINUE
CP XFER D TO &ID
O PUNCHOO FILE FTO2F001
CP XFER D OFF
-MSG5 &CONTINUE
```

```
CLOSIC PRINTER OFF
FILECEF 06 PTR
LOAC SEARCH (CLEAR XEQ NOMAP)
C PRINT FILE FT02F001
CLOSIC PRINTER ON
FILECEF 06 CON
LCAC CHANGE (CLEAR XEQ NCMAP)
&UPRINT NOW EACH PLAYER  SENDS HIS  UPCATED FILE TC THE CTHER
&UPRINT     PLAYER.  TO INITIATE TRANSFER,
-MSG6 &PRINT ENTER "R" IF YCU ARE RED, "B" IF BLUF.
&REAC ARGS
&IF &1 EQ R &SIDE = &1
&IF &1 EQ B &SIDE = &1
&PRINT YCU ENTEREC &1 . IS THIS CORRECT? ENTER "Y" OR "N".
&REAC ARGS
&IF &1 EC N &GOTO -MSG6
&IF &SICE EQ R &GCTO -RTOB
&IF &SICE NE B &GCTO -MSG6
-BTCR &CONTINUE
CP XFER C  TO &ID
O PUNCHCC FILE FTC4F001
CP XFER C OFF
&GOTC -MSG7
-RTCB &CCNTINUE
CP XFER C TO &ID
O PLNCHCC FILE FTC3F001
CP XFER C  OFF
-MSG7 &CCNTINUE
CP CLERY F
&PRINT CO YCU HAVE A FILE SPOOLED TO BE READ? ENTER "Y" OR "N".
&REAC ARGS
&IF &1 NE Y &GOTC -MSG7
O READ *
LIST FILE *
&UPRINT YOU SHOULC HAVE FILE TYPES FT02F001, FTO3F001 , FTC4FC01
&UPRINT      AND FT01F001 ON YOUR DISK AT THIS TIME.
LOAC UPCATE (CLEAR XEQ NCMAP)
ERASE FILE FTC3FOC1
ERASE FILE FTO4FOC1
&PRINT  TO PLAY ANOTHER TURN, ENTER Y. TC QUIT ENTER N.
&REAC ARGS
&IF &1 EC Y &GOTO -MSG5
&EXIT
```

```
      INTEGER RADAR, SONAR, RDISK,BDISK,HFDF,DATA,ESMDET                    DET00010
      DIMENSION PRMAX (50,50,5) ,DICE(50),NROW(2),CPA(50,2),                DET00020
     C RADAR(50,20), SONAR(50,20), DATA(50,20,2),XPLOT(50),YPLOT(50),       DET00030
     C HFDF(50,4), INTEL(50,6), ESMDET(100,5),MINDEX(10), R(4)              DET00040
      COMMON PRMAX, DATA, RADAR,SONAR,HFDF,INTEL,NROW,CPA,                  DET00050
     C NRED,NBLUE, NCOL,ID,ZTIME, EPS,ISEED1, ISEED2, ISEED3,               DET00060
     C DICE, NWRITE,NMAX,ESMDET, IFOE, DTIME, MINDEX,R,XPLOT,YPLOT          DET00070
C       SET INITIAL VALUES OF VARIABLES                                     DET00080
      NSHIP = 50                                                            DET00090
      NTERM = 5                                                             DET00100
      NCOL = 15                                                             DET00110
      NMAX = 20                                                             DET00120
      ISEED1 = 1234567                                                      DET00130
      ISEED2 = 7654321                                                      DET00140
      ISEED3 = 9182736                                                      DET00150
      IDISK = 1                                                             DET00160
      RDISK = 3                                                             DET00170
      BDISK = 4                                                             DET00180
      NWRITE = 5                                                            DET00190
      EPS = .001                                                            DET00200
      NREAD = 5                                                             DET00210
    3 NDISK = 2                                                             DET00220
C         ENTER RN SEED, TIME OF TURN & WHETHER RED OR BLUE                 DET00230
      WRITE (NTERM,102)                                                     DET00240
  102 FORMAT(' ENTER  THE RANDOM NUMBER SEED, FORMAT I7.',/)                DET00250
      READ (NREAD,103) KSEED                                                DET00260
  103 FORMAT (1I7)                                                          DET00270
      ISEED1 = ISEED1+KSEED                                                 DET00280
      ISEED2 = ISEED2 + KSEED                                               DET00290
      ISEED3 = ISEED3 + KSEED                                               DET00300
      WRITE (NTERM,104)                                                     DET00310
  104 FORMAT (' ENTER THE  TIME, IN MINUTES, OF THIS TURN, F4.0.')          DET00320
      READ (NREAD,105) TIME                                                 DET00330
  105 FORMAT (F4.0)                                                         DET00340
      DTIME = TIME                                                          DET00350
      READ (NDISK,106) ZTIME,NRED,NBLUE                                     DET00360
  106 FORMAT (F6.0,2I3)                                                     DET00370
      NROW(1) = NRED                                                        DET00380
      NROW(2) = NBLUE                                                       DET00390
    4 WRITE(NTERM,107)                                                      DET00400
  107 FORMAT (' ENTER "1" IF YOU ARE THE RED PLAYER, "2" IF BLUE.           DET00410
     C ',/,' FORMAT 1I1.',/)                                                DET00420
      READ (NREAD, 108) ID                                                  DET00430
  108 FORMAT (1I1)                                                          DET00440
```

```
      IF (IC .NE. 1 .AND. ID .NE. 2) GO TO 4                            DET00450
      IF (ID .EQ. 1 ) IFOE = 2                                          DET00460
      IF (ID .EQ. 2) IFOE = 1                                           DET00470
C       ZERO OUT ARRAYS                                                 DET00480
      DO 20 I=1,NSHIP                                                   DET00490
      CPA (I,1) = 0.0                                                   DET00500
      CPA (I,2) = 0.0                                                   DET00510
       DICE(I) = 0.0                                                    DET00520
        DO 13 J=1,NCOL                                                  DET00530
        RADAR(I,J) = 0                                                  DET00540
        SONAR(I,J) =0                                                   DET00550
      DATA(I,J,1) = 0                                                   DET00560
      DATA (I,J,2) = 0                                                  DET00570
   13   CONTINUE                                                        DET00580
        DO 14 K =1,4                                                    DET00590
      MINDEX(K + 6) = 0                                                 DET00600
          HFDF(I,K) = 0                                                 DET00610
   14   CONTINUE                                                        DET00620
        DO 15 L=1,6                                                     DET00630
          INTEL(I,L) = 0                                                DET00640
      MINDEX (L) = 0                                                    DET00650
   15   CONTINUE                                                        DET00660
         DO 16 L = 1,5                                                  DET00670
          ESMDET (I,L)=  0                                              DET00680
   16   CONTINUE                                                        DET00690
   20 CONTINUE                                                          DET00700
C     READ DATA FROM DISK 2 INTO DATA ARRAYS                            DET00710
      DO 30 I=1,NRED                                                    DET00720
      READ (NDISK,101) (DATA (I,J,1), J=1,NCOL)                         DET00730
  101 FORMAT (15I4)                                                     DET00740
   30 CONTINUE                                                          DET00750
      DO 32  I=1,NBLUE                                                  DET00760
      READ (NDISK,101) (DATA(I,J,2),J=1,NCOL)                           DET00770
   32 CONTINUE                                                          DET00780
C       IF THIS IS TURN 1, CALL NUMBER. IF NOT READ IDISK               DET00790
      IF (ZTIME .LE. EPS .OR. TIME .LE. EPS) CALL NUMBER                DET00800
      IF(ZTIME .LE. EPS .OR. TIME  .LE. EPS) GO TO 33                   DET00810
      READ (IDISK,109)(((PRMAX(I,J,K),I = 1,NMAX),J= 1,NMAX),K = 1,5)  DET00820
  109 FORMAT (20F4.3)                                                   DET00830
   33 REWIND IDISK                                                      DET00840
C       REST TIME IF OVER 24 HRS.                                       DET00850
      ZTIME = ZTIME + TIME                                              DET00860
      IF (ZTIME .GT. 1440.) ZTIME = ZTIME - 1440.                       DET00870
      IF (TIME .GT. EPS) CALL MOVE(TIME)                                DET00880
C     WRITE UPDATED INFO BACK ON MASTER FILE AND CREATE  FT03 OR        DET00890
C       FT04 RESPECTIVELY. WRITE INFO ON FT01 ALSO.                     DET00900
C         REWIND DISK WITH DATA BASE ON IT FIRST.                       DET00910
      WRITE(IDISK, 109)(((PRMAX(I,J,K),I=1,NMAX),J=1,NMAX),K= 1,5)      DET00920
```

```
      REWIND  NDISK                                                     DETC0930
      WRITE (NDISK,106) ZTIME,NRED,NBLUE                                DETC0940
      DO 35 I = 1,NRED                                                  DETC0950
        WRITE (NDISK,101) (DATA(I,J,1), J=1,NCOL)                       DETC0960
   35 CONTINUE                                                          DETC0970
      DO 37 I=1,NBLUE                                                   DETC0980
        WRITE (NDISK,101) (DATA(I,J,2), J=1,NCOL)                       DETC0990
   37 CONTINUE                                                          DETC1000
      IF (ID .EQ. 2) GO TO 40                                           DETC1010
      WRITE (RDISK,110) ZTIME,NRED                                      DETC1020
  110 FORMAT (F6.0,I3)                                                  DETC1030
      DO 40 I= 1,NRED                                                   DETC1040
        WRITE (RDISK,101) (DATA(I,J,1) ,J = 1,NCOL)                     DETC1050
   40 CONTINUE                                                          DETC1060
      IF (ID .EQ. 1) GO TO 97                                           DETC1070
      WRITE (BDISK,110) ZTIME,NBLUE                                     DETC1080
      DO 97 I=1,NBLUE                                                   DETC1090
        WRITE (BDISK,101) (DATA(I,J,2), J=1,NCOL)                       DETC1100
   97 CONTINUE                                                          DETC1110
      IF (TIME .GT. EPS) CALL DETECT (TIME)                             DETC1120
      R(1) = 1000.                                                      DETC1130
      R(2) = 0.0                                                        DETC1140
      R(3) = 1000.0                                                     DETC1150
      R(4) = 0.0                                                        DETC1160
      KTIME = ZTIME/60.                                                 DETC1170
      IMIN = 60. * ((ZTIME/60.) - FLOAT(KTIME))                         DETC1180
      M = MINDEX(10)                                                    DETC1190
      NUNIT = NROW(ID)                                                  DETC1200
      WRITE(6,55)                                                       DETC1210
   55 FORMAT (1H1)                                                      DETC1220
      NGRAPH = 3                                                        DETC1230
      IF (M  .EQ. 0) NGRAPH = 1                                         DETC1240
      IF(M .EQ. 0) GO TO 56                                             DETC1250
      CALL UTPLOT(XPLOT,YPLOT,M,R,1,1)                                  DETC1260
   56 DO 57 I = 1,NUNIT                                                 DETC1270
        XPLOT(I) = DATA(I,5,ID)                                         DETC1280
        YPLOT(I) = DATA(I,6,ID)                                         DETC1290
   57 CONTINUE                                                          DETC1300
      CALL UTPLOT(XPLOT,YPLOT,NUNIT,R,1,NGRAPH)                         DETC1310
      WRITE(6,58) KTIME,IMIN                                            DETC1320
   58 FORMAT(1H1,' STATUS OF FORCES AS OF ',I3,' HRS. ',I2,' MIN',/,/,/, DETC1330
     C'  UNIT SPEED DEPTH COURSE   X    Y  TYPE   MAX   MAX    MAX   MAX',/,  DETC1340
     C'    ID   KTS   /HT    DEG T GRID GRID       SPD   S/S    A/S   SNR',/)  DETC1350
      DO 61 I = 1,NUNIT                                                 DETC1360
        WRITE (6,60) (DATA(I,J,ID),J=1,11)                              DETC1370
   60 FORMAT ( '  ',I4,2I5,3X,8I5)                                      DETC1380
   61 CONTINUE                                                          DETC1390
      WRITE (6,62)                                                      DETC1400
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 62 FORMAT(1H1)                                                          DET01410
    DO 63 I =1,NRED                                                      DET01420
     XPLOT(I) = DATA(I,5,1)                                              DET01430
     YPLOT(I) = DATA(I,6,1)                                              DET01440
 63 CONTINUE                                                             DET01450
    CALL UTPLOT(XPLOT,YPLOT,NRED,R,1,1)                                  DET01460
    DO 65 I = 1,NBLUE                                                    DET01470
     XPLOT (I) = DATA(I,5,2)                                             DET01480
     YPLOT(I) = DATA(I,6,2)                                              DET01490
 65 CONTINUE                                                             DET01500
    CALL UTPLOT(XPLOT,YPLOT,NBLUE,R,1,3)                                 DET01510
999 STOP                                                                 DET01520
    END                                                                  DET01530
    SUBROUTINE MOVE(TIME)                                                DET01540
    INTEGER RADAR, SONAR, RDISK, BDISK, HFDF,DATA, ESMDET                DET01550
    DIMENSION PRMAX (50,50,5), DICE(50), NROW(2), CPA(50,2),             DET01560
   C RADAR(50,20), SONAR(50,20), DATA(50,20,2),XPLOT(50),YPLOT(50),      DET01570
   C HFDF(50,4), INTEL(50,6), ESMDET(100,5),MINDEX(10), R(4)             DET01580
    COMMON PRMAX,DATA,RADAR,SONAR,HFDF, INTEL, NROW, CPA,                DET01590
   C NRED,NBLUE, NCOL, ID, ZTIME, EPS, ISEED1, ISEED2, ISEED3,           DET01600
   C DICE, NWRITE,NMAX,ESMDET, IFOE, DTIME, MINDEX,R,XPLOT,YPLOT         DET01610
    THOUR = TIME/60.0                                                    DET01620
    RAD = 3.14159/180.0                                                  DET01630
    DO 10 K=1,2                                                          DET01640
    DO 5 I = 1,NBLUE                                                     DET01650
      DIST =  FLOAT(DATA(I,2,K))*THOUR                                   DET01660
      THETA = FLOAT (DATA(I,4,K))*RAD                                    DET01670
      DATA(I,5,K)= DATA(I,5,K) + (.5 +DIST*SIN(THETA))                   DET01680
      DATA(I,6,K)= DATA(I,6,K) + (.5 +DIST*COS(THETA))                   DET01690
      IF (DATA(I,5,K) .LT. 0 )DATA (I,5,K)=0                             DET01700
      IF (DATA(I,6,K) .LT. 0) DATA (I,6,K) =0                            DET01710
  5 CONTINUE                                                             DET01720
 10 CONTINUE                                                             DET01730
    RETURN                                                               DET01740
    END                                                                  DET01750
    SUBROUTINE NUMBER                                                    DET01760
    INTEGER RADAR, SONAR, RDISK,BDISK,HFDF,DATA,ESMDET                   DET01770
    DIMENSION PRMAX (50,50,5) ,DICE(50),NROW(2),CPA(50,2),               DET01780
   C RADAR(50,20), SONAR(50,20), DATA(50,20,2),XPLOT(50),YPLOT(50),      DET01790
   C HFDF(50,4), INTEL(50,6), ESMDET(100,5),MINDEX(10), R(4)             DET01800
    COMMON PRMAX, DATA,RADAR,SONAR,HFDF,INTEL,NROW,CPA,                  DET01810
   C NRED,NBLUE, NCOL,ID,ZTIME, EPS,ISEED1, ISEED2, ISEED3,              DET01820
   C DICE, NWRITE,NMAX,ESMDET, IFOE, DTIME, MINDEX,R,XPLOT,YPLOT         DET01830
    DO 30 K =1,5                                                         DET01840
     DO 20 J = 1,NMAX                                                    DET01850
     CALL RANDOM (ISEED1, DICE, 50)                                      DET01860
      DO 10 I = 1,NMAX                                                   DET01870
      PRMAX (I,J,K) = 0.0                                                DET01880
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      IF (DICE(I) .GE. .9)   GO TO 1C                                    DET01890
     PRMAX (I,J,K) = .9 * SQRT(1.0 - (DICE(I)**2/.81))                   DET01900
1C    CONTINUE                                                           DET01910
2C   CONTINUE                                                            DET01920
3C  CONTINUE                                                            DET01930
    RETURN                                                              DET01940
    END                                                                 DET01950
    SUBROUTINE DETECT(TIME)                                             DET01960
    INTEGER RADAR, SONAR, RDISK,BDISK,HFDF,DATA,ESMDET                  DET01970
    DIMENSION PRMAX (50,50,5) ,DICE(5C),NROW(2),CPA(50,2),              DET01980
   C RADAR(50,2C), SONAR(50,20), DATA(50,20,2),XPLOT(50),YPLOT(50),     DET01990
   C HFDF(50,4), INTEL(50,6), ESMDET(100,5),MINDEX(10), R(4)            DET02000
    COMMON PRMAX, DATA, RADAR,SONAR,HFDF,INTEL,NROW,CPA,                DET02010
   C NRED,NBLUE, NCOL,ID,ZTIME, EPS,ISEED1, ISEED2, ISEED3,             DET02020
   C DICE, NWRITE,NMAX, ESMDET,IFOE, CTIME, MINDEX,R,XPLOT,YPLOT        DET02030
C   DETERMINE IF THIS TURN INCLUDES AN INTELL/SURV SEGMENT              DET02040
    Z2 = ZTIME - TIME                                                   DET02050
    DO 11 NX = 1,4                                                      DET02060
     HR = 360.0 *(NX-1)                                                 DET02070
     IF (ZTIME .GE. HR .AND. Z2 .LE. HR) GO TO 12                       DET02080
11  CONTINUE                                                            DET02090
    GO TO 13                                                            DET02100
12   CALL SPOOK                                                         DET02110
C      DETERMINE ANY INTELLIGENCE FROM HF COMMS                         DET02120
13   CALL RANDOM (ISEED2, DICE, 50)                                     DET02130
    N = 0                                                               DET02140
    NN = NROW(IFOE)                                                     DET02150
    DO 16 I = 1,NN                                                      DET02160
     IF (DATA(I,1,IFOE) .LE. 0) GO TO 16                                DET02170
     IF (DATA (I,15,IFOE) .LE. 0 ) GO TO 16                             DET02180
     IF ( DICE (I) .LE. .79) GO TO 16                                   DET02190
     N= N+1                                                             DET02200
     HFDF(N,1) = DATA(I,1,IFOE)                                         DET02210
      HFDF(N,2) = DATA (I,7,IFOE)                                       DET02220
     HFDF(N,3) = DATA (I,5,IFOE)                                        DET02230
     HFDF (N,4) = DATA (I,6,IFOE)                                       DET02240
     XPLOT(N) = DATA(I,5,IFOE)                                          DET02250
     YPLOT(N) = DATA(I,6,IFOE)                                          DET02260
16  CONTINUE                                                            DET02270
    MINDEX(10) = N                                                      DET02280
    IF (N .EQ. C) GO TO 23                                              DET02290
    WRITE (NWRITE,18)                                                   DET02300
18  FORMAT (' ',15X,'HF DETECTIONS OF ENEMY COMMS',/,14X,               DET02310
   C ' X COORD  Y COORD ',/)                                            DET02320
    DO 20 I=1,N                                                         DET02330
    WRITE(NWRITE,19)    (HFDF(I,J),J=3,4)                               DET02340
19  FORMAT (' ', 12X,2I6,/)                                             DET02350
2C  CONTINUE                                                            DET02360
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C       CHECK PLATFORM VS PLATFORM DETECTIONS                                  DET0237C
   23 LIGHT =0                                                                 DET02380
      IF (ZTIME .GT. 360. .AND. ZTIME .LT. 1080.) LIGHT = 1                    DET0239C
      IUNIT = NROW(ID)                                                         DET02400
      DO 50 I = 1,IUNIT                                                        DET02410
       IF (DATA(I,1,ID) .EQ. 0) GO TO 50                                       DET0242C
       ITYPE = DATA(I,7,ID) - (1000 * ID)                                      DET02430
C      IS UNIT A SUBMARINE?                                                    DET02440
       IF (ITYPE .GE. 200 .OR. ITYPE .LT. 100) GO TO 40                        DET02450
       CALL NLPCPA(I,TIME)                                                     DET02460
C      IF SONAR PASSIVE AND SPEED LE 22 KNOTS  CALL PASSIVE                    DET02470
       IF (DATA(I,2,ID) .GE. 23) GO TO 25                                      DET02480
       IF (DATA(I,14,ID) .EQ. 0 ) CALL PSONAR(I,1)                             DET02490
C      IS SUB DEEP?                                                            DET02500
   25  IF (DATA(I,3,ID) .EQ. 2) GO TO 30                                       DET0251C
       CALL ESM(I)                                                             DET02520
C     IF SURFACE SEARCH RADAR IS ON & SUB NOT DEEP...                          DET0253C
       IF (DATA(I,12,ID) .EQ. 1) CALL DETRAD(I)                                DET02540
C      IS SUB SURFACED & IT IS DAY CHECK VISUAL SIGHTINGS                      DET0255C
       IF(DATA(I,3,ID) .EQ. 0 .AND. LIGHT .EQ. 1) CALL VISUAL(I,ITYPE)         DET02560
C       IF SONAR ACTIVE AND SPEED LE 15 KTS.                                   DET02570
   30  IF(DATA(I,14,ID).EQ. 1 .AND. DATA(I,2,ID).LE. 15)CALL ASONAR(I)         DET02580
       GO TO 90                                                                DET02590
C      IS UNIT A SURFACE SHIP ?                                                DET02600
   40 IF (ITYPE .LT. 300) GO TO 50                                             DET02610
       CALL NLPCPA(I,TIME)                                                     DET0262C
       CALL ESM(I)                                                             DET02630
       IF (LIGHT .EQ. 1) CALL VISUAL(I,ITYPE)                                  DET02640
C      IS EITHER AIR OR SURFACE SEARCH RADAR ON?                               DET02650
       IF(DATA(I,12,ID) .EQ. 1 .OR.DATA(I,13,ID) .EQ. 1) CALL DETRAD(I)        DET0266C
C      IF SONAR PASSIVE AND SPEED LESS THAN 17, CALL PASSIVE SONAR             DET0267C
       IF(DATA(I,14,ID).EQ.0 .AND. DATA(I,2,ID) .LE.17)CALL PSONAR(I,2)        DET02680
C       IF SONAR ACTIVE AND SPEED LT 15 KNOTS, CALL ACTIVE SONAR               DET02690
       IF(DATA(I,14,ID).EQ.1.AND. DATA(I,2,ID) .LE. 15)CALL ASONAR(I)          DET02700
       GO TO 90                                                                DET0271C
   50 ITYPE = ITYPE - 200                                                      DET02720
C      UNIT IS AN AIRCRAFT. IF IT IS DAY, ALL AIRCRAFT CALL VISUAL             DET02730
       CALL NLPCPA(I,TIME)                                                     DET02740
       IF (LIGHT .EQ. 1) CALL VISUAL(I,ITYPE)                                  DET02750
C IF AIRCRAFT IS FIGHTER/ ATTACK GO TO 90                                      DET02760
       IF (ITYPE .LT. 70) GO TO 90                                             DET02770
C       ALL OTHER TYPES MAKE ESM & RADAR DETECTIONS                            DET0278C
       CALL ESM(I)                                                             DET02790
       CALL DETRAD(I)                                                          DET0280C
C  ONLY SH-3 & HORMONE MAY USE DIPPING SONAR IF SPEED LT 10 & ALT LT 1         DET02810
       IF (ITYPE .EQ. 93 .AND. DATA(I,2,ID) .LE. 10 .AND.                      DET0282C
      C DATA(I,3,ID) .LE. 1) CALL ASONAR(I)                                    DET02830
   90 CONTINUE                                                                 DET02840
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      55 RETURN                                                                 DET02850
         END                                                                    DET02860
         SUBROUTINE SPOOK                                                       DET02870
         INTEGER RADAR, SONAR, RDISK,BDISK,HFDF,DATA,ESMDET                     DET02880
         DIMENSION PRMAX (50,50,5) ,DICE(50),NROW(2),CPA(50,2),                 DET02890
        C RADAR(50,20), SONAR(50,20), DATA(50,20,2),XPLOT(50),YPLOT(50),        DET02900
        C HFDF(50,4), INTEL(50,6), ESMDET(100,5),MINDEX(10), R(4)               DET02910
         COMMON PRMAX, DATA, RADAR,SONAR,HFDF,INTEL,NROW,CPA,                   DET02920
        C NRED,NBLUE, NCOL,ID,ZTIME, EPS,ISEED1, ISEED2, ISEED3,                DET02930
        C DICE, NWRITE,NMAX, ESMDET,IFOE, CTIME, MINDEX,R,XPLOT,YPLOT           DET02940
C        THIS SUBROUTINE DETERMINES THE 0001,0600, 1200                         DET02950
C         & 1800 INTELLIGENCE INFORMATION.                                      DET02960
         NUNIT = NROW(IFOE)                                                     DET02970
         N = 0                                                                  DET02980
         CALL RANDOM (ISEED3,DICE,NUNIT)                                        DET02990
         DO 11 I =1, NUNIT                                                      DET03000
          IF (DICE(I) .LT. .59) GO TO 11                                        DET03010
          IF ( DATA (I,1,IFOE) .LE. 0) GO TO 11                                 DET03020
         MCON = 0                                                               DET03030
          ID1 = DATA(I,7,IFOE) - (1000 * IFOE)                                  DET03040
          DO 9 J=12,15                                                          DET03050
           MCON = MCON + DATA (I,J,IFOE)                                        DET03060
      9  CONTINUE                                                               DET03070
          IF (DICE(I) .LT. .79 .AND. MCON .LE. 0) GO TO 11                      DET03080
C         IS UNIT SUB UNDER 15 KTS?                                             DET03090
          IF (ID1 .LT. 200 .AND. DATA(I,2,IFOE) .LT. 15) GO TO 11               DET03100
C         IS UNIT AIRCRAFT IN EMCON?                                            DET03110
          IF (ID1 .LT. 300 .AND. MCON .LE. 0 ) GO TO 11                         DET03120
C         AN INTELLIGENCE/SURVEILLANCE DETECTION HAS OCCURED                    DET03130
          N=N+1                                                                 DET03140
          IF (DICE (I) .GT. .8) GO TO 10                                        DET03150
C     ADDITIONAL INFO                                                           DET03160
         ID2= FLOAT(DATA(I,7,IFOE)/100)                                         DET03170
          INTEL(N,5) = DATA(I,7,IFOE) -       ID2*100                           DET03180
          INTEL(N,6)= ((DATA(I,4,IFOE) +5)/10.)*10                              DET03190
C        BASIC INFORMATION                                                      DET03200
     10   INTEL(N,1)= DATA(I,1,IFOE)                                            DET03210
          INTEL(N,2) = FLOAT(DATA(I,7,IFOE)/100)                                DET03220
          INTEL(N,3) = DATA(I,5,IFOE)                                           DET03230
          INTEL(N,4) = DATA(I,6,IFOE)                                           DET03240
          XPLOT(N + MINDEX(10))= DATA(I,5,IFOE)                                 DET03250
          YPLOT(N + MINDEX(10)) = DATA(I,6,IFOE)                                DET03260
     11 CONTINUE                                                                DET03270
         MINDEX(10) = MINDEX(10) + N                                            DET03280
         IF (N .EQ. 0) GO TO 99                                                 DET03290
         WRITE (NWRITE,12)                                                      DET03300
     12 FORMAT(10X,' UNIT TYPE ',3X,'X COORD YCOORD',' PLATFORM COURSE')        DET03310
         WRITE (NWRITE,13) ((INTEL(II,J), J=2,6),II=1,N)                        DET03320
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   13 FORMAT ('    ',9X,5I9,/)                                                DET03330
   99 RETURN                                                                  DET03340
      END                                                                     DET03350
      SUBROUTINE ESM (I)                                                      DET03360
      INTEGER RADAR, SONAR, RDISK,BDISK,HFDF,DATA,ESMDET                      DET03370
      DIMENSION PRMAX (50,5C,5) ,DICE(5C),NROW(2),CPA(50,2),                  DET03380
     C RADAR(50,2C), SONAR(50,20), DATA(50,20,2),XPLOT(50),YPLCT(50),         DET03390
     C HFDF(50,4), INTEL(50,6), ESMDET(100,5),MINCEX(10), R(4)                DET03400
      COMMON PRMAX, DATA, RADAR,SONAR,HFDF,INTEL,NRCW,CPA,                    DET03410
     C NRED,NBLUE, NCOL,ID,ZTIME, EPS,ISEED1, ISEED2, ISEED3,                 DET03420
     C DICE, NWRITE,NMAX, ESMDET,IFOE, CTIME, MINCEX,R,XPLCT,YPLOT            DET03430
C     THIS SUBROUTINE IS CALLED FROM DETECT. IT CALCULATES ALL POSSIBLE       DET03440
C        ESM DETECTIONS BY THE ITH RED/BLUE UNIT.  IT MUST HAVE THE           DET03450
C         RESULTS OF THE CPA SUBROUTINE AND THE NUMBER SUBROUTINE.            DET03460
C        DETECTIONS ARE PUT INTO ARRAY ESMDET                                 DET03470
      NUNIT = NROW(IFOE)                                                      DET03480
      M = 0                                                                   DET03490
C       IF RADAR IS ON AND UNIT WILL BE WITHIN 2 * RMAX * DET                 DET03500
C              A DETECTION WILL OCCUR.                                        DET03510
      DO 40 N = 1,NUNIT                                                       DET03520
       IF (DATA(N,1,IFOE) .LE. 0) GO TO 40                                    DET03530
       NTYPE = DATA(N,7,IFOE) - (1000 * IFOE)                                 DET03540
      IF (DATA(N,12,IFOE) .EQ. 0) GO TO 35                                    DET03550
       RANGE = 2 * DATA(N,9,IFOE) * PRMAX (I,N,3)                             DET03560
       IF (CPA(N,1) .GT. RANGE) GO TO 35                                      DET03570
      M = M+1                                                                 DET03580
      ESMDET(M,1) = 12                                                        DET03590
      ESMDET(M,2) = CPA(N,2)                                                  DET03600
      ESMDET(M,4) = DATA(N,1,IFOE)                                            DET03610
       ESMDET(M,5) = CPA(N,1)                                                 DET03620
      ESMDET(M,3) = NTYPE/10                                                  DET03630
C    IF AIR SEARCH RADAR ON, SEE IF ANY DETECTIONS                            DET03640
   35 IF(DATA(N,13,IFOE) .LE. 0) GO TO 40                                     DET03650
      RANGE = 2 * DATA(N,10,IFOE) * PRMAX(I,N,3)                              DET03660
      IF (CPA(N,1) .GT. RANGE) GO TO 40                                       DET03670
       M = M + 1                                                              DET03680
      ESMDET(M,1) = 13                                                        DET03690
      ESMDET (M,2)  = CPA(N,2)                                                DET03700
      ESMDET (M,4) = DATA(N,1,IFOE)                                           DET03710
      ESMDET (M,3) = NTYPE /10                                                DET03720
       ESMDET (M,5) = CPA(N,1)                                                DET03730
   40 CONTINUE                                                                DET03740
      IF (M .EQ. C) GO TO 60                                                  DET03750
      WRITE (NWRITE,50) DATA(I,1,ID)                                          DET03760
   50 FORMAT( /, ' ESM INTERCEPTS BY UNIT',I5,/,7X,' RADAR ',2X,              DET03770
     C ' BEARING ',1X,' PLATFORM')                                            DET03780
      DO 56 II=1,M                                                            DET03790
      WRITE (NWRITE,55) (ESMDET(II,JJ), JJ = 1,3)                             DET03800
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   55 FORMAT('  ',3I10)                                                        DET03810
   56 CONTINUE                                                                DET03820
      WRITE (NWRITE,57)                                                       DET03830
   57 FORMAT(' RADAR TYPE 12 = SURFACE SEARCH TYPE 13 = AIR SEARCH',/)        DET03840
      WRITE(6,58) DATA(I,1,ID)                                                DET03850
   58 FORMAT (/,/,'  ESMDET, UMPIRE VERSION ID =',I4,/,                       DET03860
     C 5X,' RADAR  BEARING  PLATFORM ID NO. CPA RANGE',/)                     DET03870
      DO 61 II = 1,M                                                          DET03880
      WRITE (6,59) (ESMDET(II,JJ),JJ = 1,5)                                   DET03890
   59 FORMAT (' ',5I8)                                                        DET03900
   61 CONTINUE                                                                DET03910
      WRITE(6,57)                                                             DET03920
   60 RETURN                                                                  DET03930
      END                                                                     DET03940
      SUBROUTINE DETRAD (I)                                                   DET03950
      INTEGER RADAR, SONAR, RDISK,BDISK,FFDF,DATA,ESMDET                      DET03960
      DIMENSION PRMAX (50,50,5) ,DICE(50),NROW(2),CPA(50,2),                  DET03970
     C RADAR(50,20), SONAR(50,20), DATA(50,20,2),XPLOT(50),YPLOT(50),         DET03980
     C FFDF(50,4), INTEL(50,6), ESMDET(100,5),MINDEX(10), R(4)                DET03990
      COMMON PRMAX, DATA, RADAR,SONAR,FFDF,INTEL,NROW,CPA,                    DET04000
     C NRED,NBLUE, NCOL,ID,ZTIME, EPS,ISEED1, ISEED2, ISEED3,                 DET04010
     C DICE, NWRITE,NMAX, ESMDET,IFOE, CTIME, MINDEX,R,XPLOT,YPLOT            DET04020
C       THIS ROUTINE IS CALLED FROM DETECT. IT CALCULATES ALL                 DET04030
CC      POSSIBLE RADAR DETECTIONS OF THE ITH RED/BLUE UNIT AGAINST            DET04040
CC      EACH NTH BLUE/RED UNIT. NEEDS INPUTS FROM SUBROUTINE                  DET04050
CC      NUMBER AND CPA. AIR SEARCH RADARS ONLY DETECT AIR TARGETS AND         DET04060
CC     AND SURFACE SEARCH RADARS ONLY DETECT SURFACE TARGETS.                 DET04070
C      DETECTIONS ARE STORED IN ARRAY RADAR.                                  DET04080
      NUNIT = NROW(IFOE)                                                      DET04090
      M = 0                                                                   DET04100
      DO 50 N = 1,NUNIT                                                       DET04110
       IF (DATA(N,1,IFOE) .EQ. 0) GO TO 50                                    DET04120
       ITGT = DATA(N,7,IFOE) - (1000 * IFOE)                                  DET04130
C      IF S/S RADAR OFF, SKIP TO NEXT RADAR                                   DET04140
       IF (DATA(I,12,ID) .EQ. 0) GO TO 25                                     DET04150
C      IF DEPTH/HT NOT EQUAL TO 0, TGT IS NOT ON SURFACE                      DET04160
       IF( DATA(N,3,IFOE) .NE. 0) GO TO 25                                    DET04170
        SRANGE = PRMAX(I,N,1) * DATA(I,9,ID)                                  DET04180
       IF (ITGT .LT. 200) SRANGE = SRANGE * .5                                DET04190
       IF(CPA(N,1) .GT. SRANGE) GO TO 25                                      DET04200
      M = M+1                                                                 DET04210
       RADAR(M,1) = DATA(N,1,IFOE)                                            DET04220
       RADAR(M,2) = DATA(N,7,IFOE)                                            DET04230
       RADAR(M,3) = 12                                                        DET04240
       RADAR(M,4) = DATA(N,4,IFOE)                                            DET04250
       RADAR(M,5) = DATA(N,5,IFOE)                                            DET04260
       RADAR(M,6) = DATA(N,6,IFOE)                                            DET04270
       RADAR(M,7) = DATA(N,2,IFOE)                                            DET04280
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      RADAR(M,8) = 1                                                    DET04290
      RADAR(M,9) = CPA(N,1)                                             DET04300
      RADAR(M,10) =CPA(N,2)                                             DET04310
      XPLOT(M + MINDEX(10)) = DATA(N,5,IFOE)                            DET04320
      YPLOT(M + MINDEX(10)) = DATA(N,6,IFOE)                            DET04330
      GO TO 50                                                          DET04340
C       IF AIR SEARCH RADAR ON AND TGT IS AN AIRCRAFT.                  DET04350
   25 IF (DATA(I,13,ID) .LE. 0) GO TO 50                                DET04360
      IF (ITGT .LT. 200 .OR. ITGT .GE. 300) GO TO 50                    DET04370
      ARANGE = PRMAX(I,N,2) * DATA(I,10,ID)                             DET04380
      IF (CPA(N,1) .GT. ARANGE) GO TO 50                                DET04390
      M = M+1                                                           DET04400
      DO 30 J = 1,7                                                     DET04410
       RADAR(M,J) = DATA(N,J,IFOE)                                      DET04420
   30  CONTINUE                                                         DET04430
      XPLOT(M + MINDEX(10)) = DATA(N,5,IFOE)                            DET04440
      YPLOT(M + MINDEX(10)) = DATA (N,6,IFOE)                           DET04450
      RADAR(M,3) = 13                                                   DET04460
      RADAR(M,2) = DATA(N,7,IFOE)                                       DET04470
      RADAR(M,7) = DATA(N,2,IFOE)                                       DET04480
      RADAR(M,8) = 1                                                    DET04490
      RADAR(M,9) = CPA(N,1)                                             DET04500
      RADAR(M,10) =CPA(N,2)                                             DET04510
   50 CONTINUE                                                          DET04520
      MINDEX(10) = MINDEX(10) + M                                       DET04530
      IF (M .EQ. 0) GO TO 99                                            DET04540
C       PRINT OUT RESULTS FOR UNIT I                                    DET04550
      WRITE(NWRITE,60) DATA(I,1,ID)                                     DET04560
   60 FORMAT(/,/,' RADAR DETECTIONS BY UNIT ',I4,/,                     DET04570
     C8X,' RADAR TYPE',2X,'COURSE',3X,'X COORD YCOORD',2X,'SPEED',      DET04580
     C 3X,'COMP.',/)                                                    DET04590
      DO 75 II = 1,M                                                    DET04600
       WRITE (NWRITE,70) (RADAR(II,JJ),JJ=3,8)                          DET04610
   70 FORMAT (' ',8X,6I8)                                               DET04620
   75 CONTINUE                                                          DET04630
      WRITE (6,76) DATA(I,1,ID)                                         DET04640
   76 FORMAT (/,/,' UMPIRE VERSION OF RADAR DETECTIONS, UNIT ',I4,/      DET04650
     C ,4X,' ID',2X,'TYPE ','RADAR',3X,'CSE  ','X GRID Y GRID ',       DET04660
     C 'SPEED',1X,'COMP',' CPA RGE & BRG ')                             DET04670
      DO 78 II = 1,M                                                    DET04680
       WRITE (6,77) (RADAR(II,JJ), JJ = 1,10)                           DET04690
   77  FORMAT (' ',8I6,3X,2I6)                                          DET04700
   78 CONTINUE                                                          DET04710
   99 RETURN                                                            DET04720
      END                                                               DET04730
      SUBROUTINE ASONAR(I)                                              DET04740
      INTEGER RADAR, SONAR, RDISK,BDISK,IFDF,DATA,ESMDET                DET04750
      DIMENSION PRMAX (50,50,5) ,DICE(50),NROW(2),CPA(50,2),            DET04760
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      C RADAR(50,20), SONAR(50,20), DATA(50,20,2),XPLOT(50),YPLOT(50),    DETC477C
      C IFDF(50,4), INTEL(50,6), ESMDET(100,5),MINDEX(10), R(4)           DET04780
        COMMON PRMAX, DATA, RADAR,SONAR,IFDF,INTEL,NRCW,CPA,              DET04790
      C NRED,NBLUE, NCOL,ID,ZTIME, EPS,ISEED1, ISEED2, ISEED3,            DET04800
      C DICE, NWRITE,NMAX, ESMDET,IFOE, DTIME, MINDEX,R,XPLOT,YPLOT       DET04810
C       THIS SUBROUTINE CALCULATES ALL POSSIBLE DETECTIONS                DET04820
C       FROM ACTIVE SONAR BY THE ITH UNIT. SONAR IS                       DET04830
C       CHECKED TO BE ACTIVE  AND SPEED LESS THAN 15 KNOTS                DET04840
C       PRIOR TO CALLING THE ROUTINE.  BOTH RED AND BLUE SUBS MAY BE      DET04850
C       DETECTED REGARDLESS OF WHETHER I IS RED OR BLUE. THE              DET04860
C       DATA FROM NUMBER AND NLPCPA MUST BE AVAILABLE. THIS               DET04870
C       SUBROUTINE IS CALLED FROM DETECT AND CALLS NLPCPA.                DET04880
C     DETECTIONS ARE STORED IN ARRAY SONAR.                               DET04890
      NUNIT = NROW(IFOE)                                                  DET04900
      ISAVE = IFOE                                                        DET04910
      KUNIT = NROW(ID)                                                    DET04920
      M = 0                                                               DET04930
      DO 60 K = 1,2                                                       DET04940
      DO 50 N = 1,NUNIT                                                   DET04950
      IF (DATA(N,1,IFOE) .EQ. 0) GO TO 50                                 DET04960
        IF (I .EQ. N .AND. K .EQ. 2) GO TO 50                             DET04970
C     IS THE TARGET A SUBMARINE NOT ON THE SURFACE?                       DET04980
        ITGT = DATA(N,7,IFOE) - (1000 * IFOE)                             DET04990
        IF (DATA(N,3,IFOE) .EQ. 0 .OR. ITGT .GE. 200) GO TO 50            DET05000
        RANGE = PRMAX(I,N,3 + K) * DATA(I,11,ID)                          DET05010
        IF (CPA(N,1) .GT. RANGE) GO TO 50                                 DET05020
C       A DETECTION HAS OCCURED                                           DET05030
        M = M+1                                                           DET05040
        DO 40 IA = 1,6                                                    DET05050
          SONAR(M,IA) = DATA(N,IA,IFOE)                                   DET05060
   40   CONTINUE                                                          DET05070
        SONAR(M,2) = DATA(N,7,IFOE)                                       DET05080
        SONAR(M,7) = DATA(N,2,IFOE)                                       DET05090
        SONAR(M,8) = CPA(N,1)                                             DET05100
        SONAR(M,9) = CPA(N,2)                                             DET05110
   50   CONTINUE                                                          DET05120
        IF (K .EQ. 2) GO TO 60                                            DET05130
        NUNIT = KUNIT                                                     DET05140
        IFOE = ID                                                         DET05150
        TIME = DTIME                                                      DET05160
        CALL NLPCPA(I,TIME)                                               DET05170
   60   CONTINUE                                                          DET05180
        IFOE = ISAVE                                                      DET05190
        IF ( M .EQ. 0) GO TO 99                                           DET05200
C       PRINT OUT SONAR                                                   DET05210
        WRITE(NWRITE,70) DATA(I,1,ID)                                     DET05220
   70   FORMAT (/,/,' ACTIVE SONAR DETECTIONS BY UNIT ',I4,/,17X          DET05230
        C ,' DEPTH',3X,'COURSE',4X,'X COORD',1X,'Y COORD',2X,'SPEED')     DET05240
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      DO 85 II = 1,M                                                    DET05250
       WRITE (NWRITE,80)(SONAR(II,JJ),JJ = 3,7)                         DET05260
   80  FORMAT (' ',14X,2I7,6X,3I7)                                      DET05270
   85 CONTINUE                                                          DET05280
      WRITE(6,86) DATA(I,1,ID)                                          DET05290
   86 FORMAT( /,/,' ACTIVE SONAR ARRAY, UMPIRE VERSION, UNIT',I4,/      DET05300
     C ,4X,' ID  TYPE',2X,' DEPTH',' COURSE',' X',4X,' Y',4X,'SPD',     DET05310
     C 2X,'CPA DIST & BRG')                                             DET05320
      DO 88 II = 1,M                                                    DET05330
       WRITE(6,87) (SONAR(II,JJ), JJ = 1,9)                             DET05340
   87  FORMAT(' ',7I6,2X,2I6)                                           DET05350
       XPLOT(MINDEX(10) + II) = SONAR(II,5)                             DET05360
       YPLOT(MINDEX(10) + II) = SONAR(II,6)                             DET05370
   88 CONTINUE                                                          DET05380
   99 MINDEX(10) = MINDEX(10) + M                                       DET05390
      RETURN                                                            DET05400
      END                                                               DET05410
      SUBROUTINE NLPCPA(I,TIME)                                         DET05420
      INTEGER RADAR, SONAR, RDISK,BDISK,FFDF,DATA,ESMDET                DET05430
      DIMENSION PRMAX (50,50,5) ,DICE(50),NROW(2),CPA(50,2),            DET05440
     C RADAR(50,20), SONAR(50,20), DATA(50,20,2),XPLOT(50),YPLOT(50),   DET05450
     C FFDF(50,4), INTEL(50,6), ESMDET(100,5),MINDEX(10), R(4)          DET05460
      COMMON PRMAX, DATA, RADAR,SONAR,FFDF,INTEL,NROW,CPA,              DET05470
     C NRED,NBLUE, NCOL,ID,ZTIME, EPS,ISEED1, ISEED2, ISEED3,           DET05480
     C DICE, NWRITE,NMAX, ESMDET,IFOE, CTIME, MINDEX,R,XPLOT,YPLOT      DET05490
C       FOR THE ITH RED/BLUE UNIT DETERMINE THE RANGE AND BEARING       DET05500
C       OF THE CPA FOR EACH OPPOSING UNIT. N SUBSCRIPTS THE             DET05510
C       OPPOSING UNITS AND CPA(R,B) STORES THE INFO WHERE R = RANGE     DET05520
C      AND B = BEARING IN DEGREES TRUE FROM THE ITH UNIT.               DET05530
       RAD = 3.14159/ 180.0                                             DET05540
       T = TIME/60.                                                     DET05550
       NUNIT = NROW(IFOE)                                               DET05560
       A = FLOAT(DATA(I,5,ID))                                          DET05570
       B = FLOAT(DATA(I,6,ID))                                          DET05580
       D2 = T * FLOAT(DATA(I,2,ID))                                     DET05590
       ETA = RAD * FLOAT(DATA(I,4,ID))                                  DET05600
       XDIST =  D2 * SIN(ETA)                                           DET05610
       YDIST = D2* COS(ETA)                                             DET05620
       DO 50 N = 1,NUNIT                                                DET05630
C       CALCULATE X1 & X2, THE RELATIVE POSITION OF THE NTH UNIT        DET05640
C       AT ZTIME - TIME.                                                DET05650
        THETA = FLOAT(DATA(N,4,IFOE))*RAD                               DET05660
        D1 =  T * (FLOAT(DATA(N,2,IFOE)))                               DET05670
        X2 = DATA(N,5,IFOE)                                             DET05680
       Y2 = DATA(N,6,IFOE)                                              DET05690
       X1 = X2 + XDIST - D1 * SIN(THETA)                                DET05700
       Y1 = Y2 + YDIST - D1 * COS(THETA)                                DET05710
C    CHECK IF SLOPE OF DRM LINE IS INFINITE                             DET05720
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      IF (ABS(X2-X1) .LE. EPS) GO TO 16                                  DET05730
C     CALCULATE SLOPE OF DRM                                             DET05740
      DX = (Y2 - Y1)/(X2-X1)                                             DET05750
      GO TO 18                                                           DET05760
   16 IF (ABS(Y2-Y1) .LT. EPS) GO TO 30                                  DET05770
      X = X2                                                             DET05780
      Y = B                                                              DET05790
      IF (B .GT. Y1 .AND. B .GT. Y2 .AND. Y1 .GT. Y2) GO TO 35           DET05800
      IF (B .GT. Y1 .AND. B .GT. Y2 .AND. Y1 .LT. Y2) GO TO 30           DET05810
      IF (B .LT. Y1 .AND. B .LT. Y2 .AND. Y1 .GT. Y2) GO TO 30           DET05820
      IF (B .LT. Y1 .AND. B .LT. Y2 .AND. Y1 .LT. Y2) GO TO 35           DET05830
      GO TO 40                                                           DET05840
   18 X = (A + B*DX + X1*DX*DX - DX*Y1)/(1.0 + DX **2)                   DET05850
      Y = (X - X1) * DX + Y1                                             DET05860
C     SEE IF THE CALCULATED CPA (X,Y) OCCURS BETWEEN (X1,Y1)             DET05870
C     AND (X2,Y2).  IF NOT SET X,Y TO THE CLOSEST ENDPOINT               DET05880
      IF (X .LT. X1 .AND. X .LT. X2 .AND. X1 .GT. X2 ) GO TO 30          DET05890
      IF (X .LT. X1 .AND. X .LT. X2 .AND. X1 .LT. X2) GO TO 35           DET05900
      IF (X .GT. X1 .AND. X .GT. X2 .AND. X1 .LT. X2) GO TO 30           DET05910
      IF (X .GT. X1 .AND. X .GT. X2 .AND. X1 .GT. X2) GO TO 35           DET05920
      GO TO 40                                                           DET05930
   30 X = X2                                                             DET05940
      Y = Y2                                                             DET05950
      GO TO 40                                                           DET05960
   35 X = X1                                                             DET05970
      Y = Y1                                                             DET05980
C     CALCULATE DISTANCE TO (X,Y) FROM (A,B)                             DET05990
   40 CPA (N,1) = SQRT ((X-A)**2 + (Y - B)**2)                           DET06000
C     IF CPA IS VERY "SMALL", SET IT TO EPS                              DET06010
      IF (CPA(N,1) .LT. EPS) CPA(N,1) = EPS                              DET06020
      TAU = ARSIN ((X-A)/CPA(N,1))                                       DET06030
      IF ((X .LT. A) .AND. (Y .GE. B)) TAU = TAU + 2.0 * 3.14159         DET06040
      IF ((X .GT. A) .AND. (Y .LT. B)) TAU = 3.14159 - TAU               DET06050
      IF ((X .EQ. A) .AND. (Y .LT. B)) TAU =  3.14159                    DET06060
      IF ((X .LT. A) .AND. (Y .LT. B)) TAU  =   3.14159 - TAU            DET06070
      CPA(N,2)  = TAU/RAD                                                DET06080
   50 CONTINUE                                                           DET06090
      RETURN                                                             DET06100
      END                                                                DET06110
      SUBROUTINE VISUAL(I,ITYPE)                                         DET06120
      INTEGER RADAR, SONAR, RDISK,BDISK,HFDF,DATA,ESMDET                 DET06130
      DIMENSION PRMAX (50,50,5) ,DICE(50),NROW(2),CPA(50,2),             DET06140
     C RADAR(50,20), SONAR(50,20), DATA(50,20,2),XPLOT(50),YPLOT(50),    DET06150
     C HFDF(50,4), INTEL(50,6), ESMDET(100,5),MINDEX(10), R(4)           DET06160
      COMMON PRMAX, DATA, RADAR,SONAR,HFDF,INTEL,NROW,CPA,               DET06170
     C NRED,NBLUE, NCOL,ID,ZTIME, EPS,ISEED1, ISEED2, ISEED3,           DET06180
     C DICE, NWRITE,NMAX, ESMDET,IFOE,DTIME, MINDEX,R,XPLOT,YPLOT       DET06190
C     THIS SUBROUTINE CALLED FROM DETECT. CPA'S FROM                     DET06200
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C     NLECPA ARE USED  TC CHECK FOR VISUAL SIGHTINGS                          DET06210
C     FRCM 0600 TO 1800 HRS GAME TIME. SHIPS AND SURFACED                     DET06220
C      SUBMARINES DETECT ALL UNITS WITHIN 10 MILES.                           DET06230
C      AIRCRAFT DETECT ALL UNITS WITHIN 20 NAUT MILES.                        DET06240
C      SUBMERGED SUBMARINES ARE NOT DETECTED. ALL                             DET06250
C      DETECTIONS ARE STORED IN ARRAY RADAR, COL 10-20.                       DET06260
       RANGE = 10.0                                                           DET06270
       IF ( ITYPE .LT. 100) RANGE = 20.0                                      DET06280
       M = 0                                                                  DET06290
       NUNIT = NROW(IFOE)                                                     DET06300
       DO 50 N = 1, NUNIT                                                     DET06310
        IF (DATA(N,1,IFOE) .EQ. 0) GO TO 50                                   DET06320
        NTYPE =DATA(N,7,IFOE) -(1000* IFOE)                                   DET06330
       IF(DATA(N,3,IFOE) .GT. 0 .AND.NTYPE .LT. 200) GO TO 50                 DET06340
        IF (CPA(N,1) .GT. RANGE) GO TO 50                                     DET06350
C       A DETECTION HAS OCCURED                                               DET06360
       M = M+1                                                                DET06370
        RADAR(M,19) = DATA(N,1,IFOE)                                          DET06380
        RADAR(M,11) = DATA(N,7,IFOE)                                          DET06390
        RADAR(M,12) = DATA(N,3,IFOE)                                          DET06400
        RADAR(M,13) = DATA(N,4,IFOE)                                          DET06410
        RADAR(M,14) = DATA(N,5,IFOE)                                          DET06420
        RADAR(M,15) = DATA(N,6,IFOE)                                          DET06430
        RADAR(M,17) = 1                                                       DET06440
        RADAR(M,16) = CPA(N,2)                                                DET06450
        RADAR(M,18) = CPA(N,1)                                                DET06460
        XPLOT(M + MINDEX(10)) = DATA(N,5,IFOE)                                DET06470
        YPLOT(M + MINDEX(10)) = DATA(N,6,IFOE)                                DET06480
    50 CONTINUE                                                               DET06490
       MINDEX(10) = M + MINDEX(10)                                            DET06500
       IF (M .EQ. 0) GO TO 99                                                 DET06510
       WRITE(NWRITE,60) DATA(I,1,ID)                                          DET06520
    60 FORMAT (/,/,' VISUAL DETECTIONS BY UNIT ',I4,/,9X,                     DET06530
      C ' TYPE',3X,'ALT.',2X,'COURSE',1X,'X COORD YCOORD',2X,'BEARING',       DET06540
      C ' COMP.')                                                             DET06550
       DO 70  II = 1,M                                                        DET06560
       WRITE (NWRITE,65) (RADAR(II,JJ) ,JJ = 11,17)                           DET06570
    65 FORMAT( ' ',6X,5I7,3X,2I6)                                             DET06580
    70 CONTINUE                                                               DET06590
       WRITE (6,73) DATA(I,1,ID)                                              DET06600
    73 FORMAT (/,/,' UMPIRE VERSION OF VISUAL SIGHTINGS, UNIT ',I4,/,         DET06610
      C '   TYPE',4X,'ALT.',1X,'COURSE',1X,'X COORD YCOORD',' BRG ',          DET06620
      C 2X,'COMP CPA RNG',' ID')                                              DET06630
       DO 75 II = 1,M                                                         DET06640
        WRITE (6,74) (RADAR(II,JJ), JJ = 11,19)                               DET06650
    74 FORMAT (' ',3I6,4X,6I6)                                                DET06660
    75 CONTINUE                                                               DET06670
    99 RETURN                                                                 DET06680
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      END                                                                DET06690
      SUBROUTINE FSONAR(I,IPLAT)                                         DET06700
      INTEGER RADAR, SONAR, RDISK,BDISK,FFDF,DATA,ESMDET                 DET06710
      DIMENSION PRMAX (50,5C,5) ,DICE(5C),NROW(2),CPA(50,2),             DET06720
     C  RADAR(50,2C), SONAR(50,20), DATA(50,20,2),XPLCT(50),YPLCT(50),   DET06730
     C  FFDF(50,4), INTEL(50,6), ESMDET(100,5),MINDEX(10), R(4)          DET06740
      COMMON PRMAX, DATA, RADAR,SCNAR,FFDF,INTEL,NRCW,CPA,               DET06750
     C  NRED,NBLUE, NCOL,ID,ZTIME, EPS,ISEED1, ISEED2, ISEED3,          DET06760
     C  DICE, NWRITE,NMAX, ESMDET,IFOE,CTIME, MINDEX,R,XPLCT,YPLCT      DET06770
      M = 0                                                              DET06780
      NUNIT = NROW(IFOE)                                                 DET06790
      KUNIT = NROW(ID)                                                   DET06800
      DC 35 N = 1,NUNIT                                                  DET06810
      IF (DATA(N,1,IFOE) .LE. 0) GO TC 35                                DET06820
       IF (DATA(N,14,IFCE) .LE. 0) GO TC 35                              DET06830
C      PASSIVE DETECTION OF AN ACTIVE SCNAR                              DET06840
       RANGE = 2 * DATA(N,11,IFOE) * PRMAX(I,N,5)                        DET06850
       IF (CPA(N,1) .GT. RANGE) GC TO 35                                 DET06860
       M = M+1                                                           DET06870
       DO 33 IA = 1,7                                                    DET06880
        SCNAR(M,IA +10) = DATA(N,IA,IFCE)                                DET06890
   33  CONTINUE                                                          DET06900
       SCNAR(M,18) = CPA(N,1)                                            DET06910
       SCNAR(M,19) = CPA(N,2)                                            DET06920
       SCNAR(M,17) = DATA(N,2,IFOE)                                      DET06930
       SCNAR(M,12) = DATA(N,7,IFOE)                                      DET06940
       SCNAR (M,2C) = CPA(N,1)*(DICE(N) -.5) + CPA(N,1)                  DET06950
   35 CCNTINUE                                                           DET06960
       IF (M .EQ. 0) GO TO 50                                            DET06970
C  PRINT OUT ANY PASSIVE DETECTIONS OF ACTIVE SCNAR                      DET06980
      WRITE (NWRITE,40)DATA(I,1,ID)                                      DET06990
   4C FCRMAT (/,/,' DETECTIONS OF ACTIVE SONARS BY UNIT',I4,/            DET07000
     C ,3X,' DEPTH',2X,' BEARING',2X,' APPROX RANGE')                    DET07010
       DC 43 II = 1,M                                                    DET07020
      WRITE (NWRITE,42) SONAR(II,13),SONAR(II,19),SCNAR(II,20)           DET07030
   42 FCRMAT (' ',1I6,1I9,1I11)                                          DET07040
   43 CCNTINUE                                                           DET07050
      WRITE (6,44) DATA(I,1,ID)                                          DET07060
   44 FCRMAT (/,/,' UMPIRE  DETECTIONS CF ACTIVE SCNARS, UNIT',I5,/      DET07070
     C,4X,'ID TYPE DEPTH  CSE   X',4X,'Y   SPD  RGE  BRG')              DET07080
      DC 46 II =1,M                                                      DET07090
       WRITE(6,45) (SONAR(II,JJ),JJ=11,19)                               DET07100
   45  FCRMAT (' ',2I5,1X,7I5)                                           DET07110
   46 CCNTINUE                                                           DET07120
   5C MM = M                                                             DET07130
      DC 6C N = 1,NUNIT                                                  DET07140
      IF(DATA(N,1,IFOE) .EQ. 0) GO TO 6C                                 DET07150
      NTGT = DATA(N,7,IFOE) - (IFOE * 1CC0)                              DET07160
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      IF (NTGT .GE. 200 .AND. NTGT .LT. 300) GO TO 60                   DET07170
      IF (IPLAT .NE. 1 .OR. DATA(I,3,ID) .EQ. 0) GO TO 53               DET07180
      IF (NTGT .GE. 300 .AND. DATA(I,3,ID) .EQ. 1) GO TO 52             DET07190
       IF(DATA(N,3,IFOE) .NE. DATA(I,3,ID)) GO TO 53                    DET07200
   52 B2 = 2.0                                                          DET07210
       C = .5                                                           DET07220
       A = FLOAT ( DATA(N,2,IFOE) )/5. + 15.                            DET07230
       GO TO 54                                                         DET07240
   53  B2 = (FLOAT(DATA(N,2,IFOE))- 20.0)  /(-2.0)                      DET07250
       IF (DATA(N,2,IFOE) .LE. 20) B2 = 0.0                             DET07260
        IF (DATA(I,2,ID) .GT. 18) GO TO 60                              DET07270
       C = .4                                                           DET07280
       IF (DATA(N,2,IFOE) .GT. 15) C = .6                               DET07290
       A = C * FLOAT(15 - DATA(N,2,IFOE)) + DATA(N,2,IFOE)              DET07300
   54  B = DATA(N,2,IFOE) + B2                                          DET07310
       X = DATA(I,2,ID)                                                 DET07320
      IF (X .GT. A) A = X                                               DET07330
       Y = SQRT(B**2 *(1.0-((X/A)**2)))                                 DET07340
        IF(Y .GT. DATA(I,11,ID)) Y = DATA(I,11,ID)                      DET07350
       RANGE = Y * PRMAX(I,N,5)                                         DET07360
       IF (CPA(N,1) .GT. RANGE) GO TO 60                                DET07370
       MM = MM+1                                                        DET07380
      DO 55 IK = 1,7                                                    DET07390
       SONAR(MM,IK + 10) = DATA(N,IK,IFOE)                              DET07400
   55 CONTINUE                                                          DET07410
       SONAR(MM,18)  = CPA(N,1)                                         DET07420
       SONAR(MM,19) = CPA(N,2)                                          DET07430
   60 CONTINUE                                                          DET07440
      IF (M .EQ. MM) GO TO 99                                           DET07450
      WRITE(NWRITE,90) DATA(I,1,ID)                                     DET07460
   90 FORMAT(/,/,' PASSIVE DETECTIONS BY UNIT',I4,/,4X,                 DET07470
     C ' COURSE',2X,'SPEED',3X,'DEPTH',3X,' RANGE',1X,'BEARING')        DET07480
      M1 = M+1                                                          DET07490
      DO 93 II  = M1,MM                                                 DET07500
      WRITE(NWRITE,92) SONAR(II,14),SONAR(II,12) ,SONAR(II,13),         DET07510
     C SONAR(II,18),SONAR(II,19)                                        DET07520
   92 FORMAT(' ',3I8,3X,2I6)                                            DET07530
   93 CONTINUE                                                          DET07540
      WRITE (6,94) DATA(I,1,ID)                                         DET07550
   94 FORMAT(/,/,' UMPIRE COPY, PASSIVE SONAR DETECTIONS, UNIT ',I4,    DET07560
     C /,4X,'ID  SPD DEPTH   CSE  X',4X,'Y   TYPE  RGE  BRG')          DET07570
      DO 96 II =M1,MM                                                   DET07580
       WRITE(6,95) (SONAR (II,JJ), JJ = 11,19)                          DET07590
   95 FORMAT ( ' ',3I5,2X,6I5)                                          DET07600
   96 CONTINUE                                                          DET07610
   99 RETURN                                                            DET07620
      END                                                               DET07630
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      INTEGER DATA                                                      CHA00010
      DIMENSION DATA (50,20)                                            CHA00020
      NCOL = 15                                                         CHA00030
      NREAD = 5                                                         CHA00040
      NWRITE = 6                                                        CHA00050
      DO 9 I = 1,50                                                     CHA00060
        DO 8 J = 1,20                                                   CHA00070
         DATA (I,J) = 0                                                 CHA00080
    8   CONTINUE                                                        CHA00090
    9 CONTINUE                                                          CHA00100
   10 WRITE (NWRITE, 11)                                                CHA00110
   11 FORMAT (' ENTER 1 FOR RED, 2 FOR BLUE, FORMAT 111.',/)            CHA00120
      READ (NREAD,20) IDENT                                             CHA00130
   20 FORMAT (111)                                                      CHA00140
      IF ((IDENT .GT. 2) .OR. (IDENT .LT. 1)) GO TO 10                  CHA00150
      IDISK = IDENT + 2                                                 CHA00160
      READ (IDISK,30) ZTIME,NROW                                        CHA00170
   30 FORMAT (F6.0, I3)                                                 CHA00180
      DO 32 I=1,NROW                                                    CHA00190
        READ(IDISK,31) (DATA(I,J),J=1,NCOL)                             CHA00200
   31   FORMAT(15I4)                                                    CHA00210
   32 CONTINUE                                                          CHA00220
   39 WRITE (NWRITE,40) ZTIME,NROW                                      CHA00230
   40 FORMAT (' IT IS ',F6.0,' Z TIME. YOU HAVE  ',I3,' UNITS.',/,      CHA00240
     C ' ENTER THE ROW NUMBER OF THE UNIT YOU WISH TO CHANGE THE ',/,    CHA00250
     C ' STATUS OF, 112. "0" WILL INDICATE NO CHANGES TO ANY UNIT.',/)   CHA00260
   41 READ (NREAD,42) N                                                 CHA00270
   42 FORMAT (112)                                                      CHA00280
      IF (N .LE. 0) GO TO 59                                            CHA00290
      IF (N .GT. NROW) GO TO 39                                         CHA00300
   45 WRITE (NWRITE,46)(DATA(N,I),I=1,4)                                CHA00310
   46 FORMAT (' CODE     UNIT ID=',I4,/,                                CHA00320
     C        '   2      SPEED IS ',I4,' KTS.',/,                       CHA00330
     C        '   3      ALT/DEPTH=',I4,'*10**3 / 1=SHALLOW,2=DEEP.',/, CHA00340
     C        '   4      COURSE IS ',I4,' T.')                          CHA00350
      WRITE (NWRITE, 47) (DATA(N,I), I =12,15)                          CHA00360
   47 FORMAT ('   5    SURFACE SEARCH RADAR:',I4,'   1=ON.',/,          CHA00370
     C '   6    AIR SEARCH RADAR:    ',I4,'  0=OFF.',/,                 CHA00380
     C '   7              SONAR:  ',I4,/,                              CHA00390
     C '   8    HF COMMUNICATIONS:',I4,/,                              CHA00400
     C ' ENTER THE CODE NUMBER OF THE LINE YOU WANT TO CHANGE.',/,      CHA00410
     C ' 111.  " 0" MEANS NO CHANGES TO THIS UNIT.',/)                  CHA00420
      READ (NREAD,48) NCODE                                             CHA00430
   48 FORMAT (111)                                                      CHA00440
```

```
      IF (NCODE .LE. 1 .OR. NCODE .GT. 8) GO TO 39                      CHA00450
      WRITE (NWRITE,50) NCODE                                           CHA00460
   50 FORMAT (' ENTER THE NEW VALUE FOR CODE NO.',I2,', 1I4.',/)        CHA00470
      IF (NCODE .GT. 4) NCODE = NCODE+7                                 CHA00480
      READ (NREAD,52) DATA (N,NCODE)                                    CHA00490
   52 FORMAT (1I4)                                                      CHA00500
      IF (DATA(N,NCODE) .LT. 0) DATA (N,NCODE) = 0                      CHA00510
      IF ((NCODE .EQ.2) .AND. (DATA (N,NCODE) .GT.  DATA(N,8)))         CHA00520
     C DATA (N,NCODE) = DATA(N,8)                                       CHA00530
      IF (NCODE .EQ. 4 .AND. DATA(N,NCODE) .GE. 360) DATA (N,NCODE)= 0  CHA00540
      ITYPE = DATA(N,7) -(ICENT * 1000)                                 CHA00550
      IF (NCODE .EQ. 3 .AND. DATA(N,CODE) .NE. 0 .AND. ITYPE .GE. 300)  CHA00560
     C DATA(N,NCODE) = 0                                                CHA00570
      GO TO 45                                                          CHA00580
   59 WRITE (NWRITE,60)                                                 CHA00590
   60 FORMAT (' IF YOU WISH TO BRING AN OUT OF PLAY UNIT',/,            CHA00600
     C ' INTO PLAY OR PUT A UNIT OUT OF PLAY ( I.E. SINK IT),',/,       CHA00610
     C ' ENTER THE ROW NUMBER OF THAT UNIT, 1I2. "0" MEANS',/,          CHA00620
     C ' NO UNITS TO PUT IN OR OUT OF PLAY.',/)                         CHA00630
      READ (NREAD,42)  IDNO                                             CHA00640
      IF ( IDNO .EQ. 0) GO TO 90                                        CHA00650
      IF ( IDNO .GT. NROW) GO TO 59                                     CHA00660
      WRITE (NWRITE ,46) (DATA( IDNO,J),J =1,4)                         CHA00670
      WRITE (NWRITE, 66)                                                CHA00680
   66 FORMAT (/,' ENTER  THE NEW UNIT ID ,1I4.  "0" PUTS THE UNIT',/,   CHA00690
     C ' OUT OF PLAY.  ANY OTHER  VALUE BRINGS THE UNIT INTO ',/,       CHA00700
     C ' PLAY WITH THAT ID NUMBER.',/)                                  CHA00710
      READ (NREAD,68) DATA( IDNO,1)                                     CHA00720
   68 FORMAT (1I4)                                                      CHA00730
      IF (DATA( IDNO,1) .NE. 0) GO TO 70                                CHA00740
      DATA( IDNO,5) = 0                                                 CHA00750
      DATA( IDNO,6) = 0                                                 CHA00760
      GO TO 59                                                          CHA00770
   70 WRITE (NWRITE,72)  IDNO,DATA( IDNO,5), DATA( IDNO,6)              CHA00780
   72 FORMAT (' UNIT',I3,' IS NOW AT ',2I5,/,                           CHA00790
     C ' ENTER FORMAT I4 FIRST  THE NEW X CO-ORDINATE ',/               CHA00800
     C ,' THEN, AFTER THE SECOND > APPEARS, THE NEW Y CO-ORDINATE.',/)  CHA00810
      READ (NREAD,74) (DATA( IDNO,J),J=5,6)                             CHA00820
   74 FORMAT (1I4)                                                      CHA00830
      GO TO 59                                                          CHA00840
   90 REWIND IDISK                                                      CHA00850
      WRITE (IDISK,30) ZTIME,NROW                                       CHA00860
      DO 92 I=1,NROW                                                    CHA00870
        WRITE (IDISK,31) (DATA(I,J),J=1,NCOL)                           CHA00880
   92 CONTINUE                                                          CHA00890
   99 STOP                                                              CHA00900
      END                                                               CHA00910
```

```
      INTEGER  RDATA,BDATA,BDISK,RDISK                                  INDOOO'0
      DIMENSION RDATA(50,20), BDATA(50,2C)                              INDOOO20
      NCCL = 15                                                         INDOOC3C
      RDISK = 3                                                         INDOOO40
      BDISK = 4                                                         INDOOO5C
      NROW = 50                                                         INDOOO60
      NDISK = 2                                                         INDOOC70
      READ (RDISK,10) ZTIME, NRED                                       INDOOO80
   1C FORMAT (F6.C,1I3)                                                 INDOOC90
      DO 20 I=1,NROW                                                    INDOOC100
        DO 15 J=1,NCOL                                                  INDOOC110
        RDATA(I,J) = 0                                                  INDOOI20
        BDATA(I,J) =0                                                   INDOO130
   15   CONTINUE                                                        INDOO140
   2C CONTINUE                                                          INDOOC150
      DO 60 I=1,NRED                                                    INDOO160
        READ (RDISK,40) (RDATA(I,J) , J = 1,NCOL)                       INDOO170
   40 FORMAT (15I4)                                                     INDOC180
   60 CONTINUE                                                          INDOO190
   7? READ (BDISK,77) ZTIME, NBLUE                                      INDOC200
   77 FORMAT (F6.C,1I3)                                                 INDOO210
      DO 83 I =1,NBLUE                                                  INDOO220
        READ (BDISK,81) (BDATA (I,J) ,J=1,NCOL)                         INDOO230
   81    FORMAT (15I4)                                                  INDOO240
   83 CONTINUE                                                          INDOO250
   8S REWIND NDISK                                                      INDOO260
      WRITE (NDISK, 90) ZTIME,NREC,NBLUE                                INDOO27C
   9C FORMAT (F6.C,2I3)                                                 INDOC280
      DO 92  I=1,NRED                                                   INDCC29C
      WRITE (NDISK, 91) (RDATA(I,J),J=1,NCOL)                           INDOO300
   91 FORMAT (15I4)                                                     INDOO310
   92 CONTINUE                                                          INDOO32C
      DO 93 I=1,NBLUE                                                   INDOO330
      WRITE (NDISK, 91) (BDATA(I,J), J=1,NCOL)                          INDOC340
   93 CONTINUE                                                          INDOO350
      REWIND BDISK                                                      INDOO360
      REWIND RDISK                                                      INDOC37C
  999 STOP                                                              INDOO380
      END                                                               INDOC390
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